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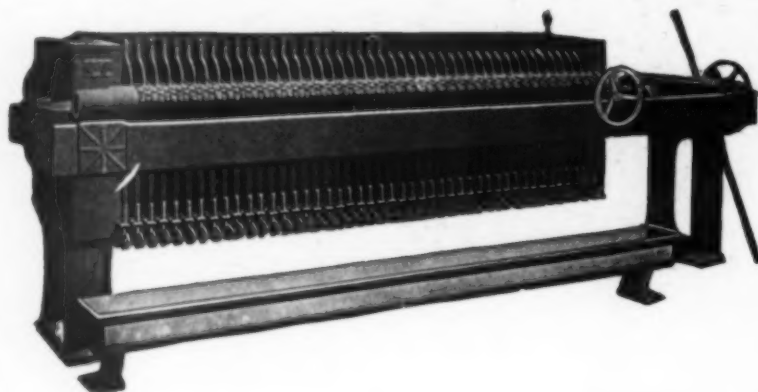
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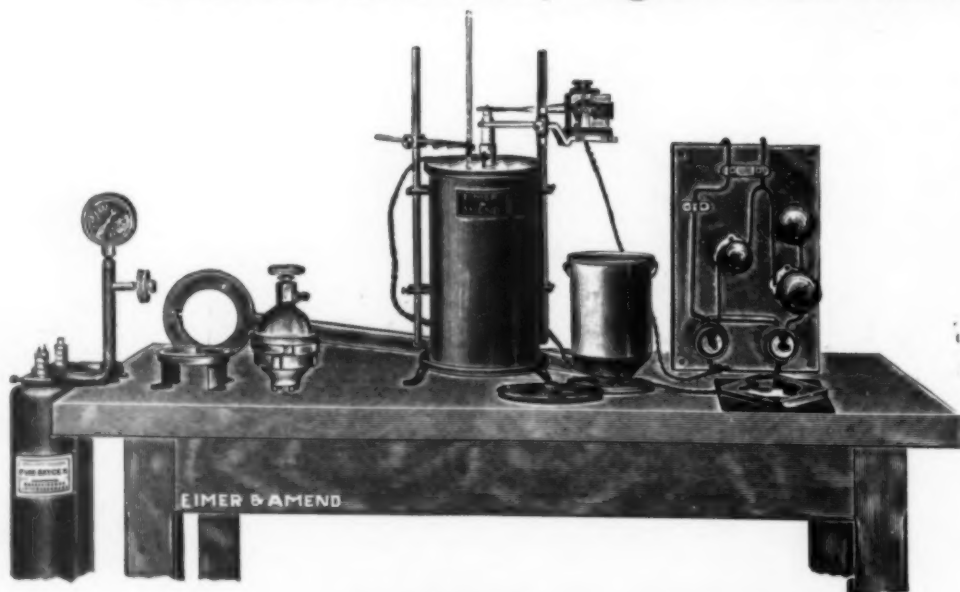
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A Word

To the Foolish

THESE words, alas, are designed for a gentleman who, probably, will never see them, because he does not read the chemical journals. He is in the chemical business, but not in the chemical profession. His money is in the works, but his heart is neither there nor in the laboratory. It is in the counting house. What we have to say to you, sir, is something you do not know. Your leading chemist, on whom you set such great store, wants to leave you. You can't understand why? Of course you can't, and we doubt if you could even if you were right here, sitting across the table from us. But now we shall make it harder still for you to understand. He is anxious to get another engagement even at a reduction of income. He is satisfied with the salary you pay him. In fact, you give him everything he asks for. His work, as work, suits him, and there is every reason to believe that it suits you.

Then what is the matter? We fear it is nothing you can remedy. You see, you are not as young as you were and your habits of mind are settled. You are a man of affairs, and that is a reputable calling. But although you are engaged in the chemical business you are not a chemist. To you chemistry means money, profit and sales, but it has not entered into your soul the way, let us say, your ambitions for your son have entered into your soul. You think, probably, that because the Doctor goes to the laboratory every day and draws his big check at the end of every month, he is satisfied. Well, now, we tell you, he is not satisfied at all. He has his dreams, just as you have yours. When he was young he heard his own tune sounded in the offing, and that was the call of chemistry, which he followed. He made good, and having done so you tendered him his present post, which he accepted. But because you are ignorant and narrow-minded and scientifically blind and deaf you can't understand that the call he heard was neither your whistle nor the clink of your coin. It was something infinitely bigger. It was the call of Science. It was the privilege, the distinction, to contribute something to human understanding. It was impersonal.

Now let us tackle the situation from another angle. That chemist of yours is dotty. He's got wheels. He wants to help humanity! Isn't that absurd? But that's his game. When he gave up pure science and embraced industry he thought that the larger purpose of industry was to augment human welfare, and that your dividends would come along on the side as some sort of honorarium. He never learned that antique slogan of yours that "Business is war." It never worried him to think that if information leaks out of the works, some competitor may profit by it, although you are very keen to forbid all communications

that might lead to this. But it stands to reason that your competitors are in about the same position as yourself, and that they know some things that you don't. Slowly, whatever any one of you knows percolates through, and in the end the whole industry has it; but so long as you and your competitors are obstinate, the industry is retarded—seriously retarded.

We know some concerns that have given up having trade secrets. There are not many of them, but they are successful, and clear out of your class. Their chemists go to meetings and tell nearly everything they know, to the amazement of competitors who straightway profit by it. But they keep ahead of the game.

Don't you think it is about time for you to rest on your laurels and retire? Then you may get someone who knows the profession as well as the business of chemistry to take your place. That will raise the class of your whole institution. It will make for progress and even greater profit in the long run. But there's no use in trying to explain it to your directors. They don't understand, either. Like you, they are, scientifically speaking, ignorant men.

Mr. Ford and Muscle Shoals

WHAT will Mr. FORD do with Muscle Shoals if he gets it? Speculation has been rife for some time as to the purpose of the automobile manufacturer in acquiring this power and industrial project. Undoubtedly his primary interest is in power, because it will enable him to produce such metals as aluminum and magnesium, which might conceivably find extensive use in automobile manufacture. That he will make nitrogen fertilizer in some form or other is a part of his proposed contract with the government, though it is not expected that he will operate the nitrate plants solely along the lines for which they were designed and built. Phosphate fertilizer undoubtedly would be included in his program. Rumor has it that he will experiment with cotton for the production of a fiber board or similar material for automobile bodies, with the object of producing a car light in weight throughout its construction. All of these are rational proposals and would logically grow out of the acquisition of an industrial and power plant situated in a country that produces minerals and cotton.

Congress will soon have an opportunity to show whether it was sincere in disapproving the plan for the United States Fixed Nitrogen Corporation on the score that it did not believe in the government going into business and that it preferred to see the Muscle Shoals properties acquired and operated by private interests. We do not favor Mr. FORD's proposal as far as it has been disclosed, for reasons which we have already set forth. It remains to be seen whether he has modified the objectionable items in the definite form of contract which he is understood to have signed.

Developing Chemists In the Industries

RECENTLY we have discussed several phases of the chemist's education as he obtains it in college. This is but the preparatory groundwork for the training that he will receive in his first few years of industrial experience, for it is in this period that he will usually discover his aptitude and fitness for his life's work. When he gets his first job in industry he cannot be sure at that stage of his training just what bent his ability will take nor what line of work he is most desirous of pursuing. If he chooses then, he does so blindly. He is likely to be influenced by a minor thing, by his admiration for some particular man who has been successful in his field or by the first job which offers an income. He is uninformed as to the range of opportunities. His college training usually will not help him to visualize the business world. But in order eventually to advance in the industry he must be able to picture in his mind the operations and processes in the manufacturing departments.

He can do no better than to seek a laboratory job in plants manufacturing heavy products from raw materials, such as acids, alkalis, coal products, metals, petroleum, oils, crude rubber or animal products. His choice among these is not so important, but may be governed by an estimate of the possible future growth of the particular one in question. If he has in the latter years of his college course been a consistent reader of technical and trade papers reflecting the economics of the technical industries, he will have some measure of information on which to base his decision.

These industries in turn may look upon their laboratory man as a raw material for other departments. While analyzing the materials, intermediate and finished products of the plant in his routine control or research operations, he must, by virtue of necessary contact with the processes and equipment, pick up considerable information on construction details, mechanical design, engineering features and business methods. He may be unobserving by nature, lazy of mind and learn very little, or he may be alert and obtain a large amount of information. His attitude at this point will largely determine his fitness to survive and develop in the field. The wise executive must eventually notice his bent and bring him into one of the departments as foreman, construction boss, engineer or efficiency man.

True, some plant managers are themselves lacking in ability to recognize human qualifications. In this case the alert chemist will seek employment elsewhere while either the manager or plant ultimately fails and falls behind in the business field; for the development of the human is far more important to the success of a business enterprise than any consideration of machinery or material.

Having eventually arrived at a better position in a department outside the laboratory, with the background of first a good character and second a technical education, the student rapidly passes the old-time operating man and is soon ready to become plant executive or salesman or fill some other coveted position. For he has now added to other experience the one most valuable of all—namely, a knowledge of the mechanism of plant apparatus and production. Knowledge based on actual physical contact with the things of industry and close association with the humans who

work with them is the greatest essential to success in all branches. The salesman, for instance, can no longer succeed by a worship of the deity of well-turned words, better known as "hot air." For the salesman who is sure of his own knowledge and strong in his own heart must succeed. No argument coined by the keenest of buyers can disturb his solicitation.

Climbing then from the first step in industry as a laboratory man, up to the second as a "straw boss," and on to the third as a department foreman, the chemist of industry is standing where he may look over the nearer landscape and get a glimpse of the peaks of executive control beyond.

Does Business Want The Soldier Bonus?

OPPOSITION to the so-called soldier bonus proposed by Congress is admittedly an unpopular rôle to assume at this time. But the situation is fraught with such vital consequences to business and industry in this country that we deem it a reasonable duty to voice our protest against the scheme and point out its economic folly. At a time when thrift and economy have been urged upon the individual and promised by the dominant political party on behalf of the government, it is proposed, for reasons purely political, to fasten upon the country the burden of raising a sum estimated at not less than \$1,500,000,000 and as much as \$5,250,000,000.

This is proposed in the name of compensation for veterans who gave their services in the late war. We would be the last to deny those men any reasonable favor, courtesy or preference. But we are wholly unconvinced that the veterans as a whole are behind the demand for the bonus to which Congress claims it is bowing in submission. Approximately two million veterans went abroad and about two million more were in the service for 6 months prior to the Armistice, making a total of about four million men under arms. Of these, 20 per cent, or 800,000, are in the American Legion, which is sponsoring the bonus on behalf of the soldier, claiming to represent his sentiment in the matter. But it is to be noted that four times that number of veterans are inarticulate as a body, to which we can add with certain knowledge that not all the American Legion favor the bonus.

Secretary MELLON has sounded a timely warning to Congress showing the necessity of reducing expenditures in order to balance the budget for the next fiscal year. Already there is in sight a deficit of \$300,000,000 which must be met by either reducing our expenses or increasing our income. The adoption of the bonus plan would only aggravate this financial situation, because it would augment the deficit and necessitate still further taxation. Where is the money coming from? We cannot commit the folly of Europe and produce it on the printing press. We must raise it in cash by taxation. Subterfuges will avail us nothing. As for the American Legion, it dismisses the matter with neatness and despatch by observing that it is not concerned with the method of raising money.

Our own analysis of the situation leads us to believe that Congress will commit an economic blunder if it passes legislation for a soldier bonus. It will still further unbalance our national budget and delay the return to normal business conditions. It will add to the burden of taxation which it is pledged to lighten. And all this on account of political expediency and an unwillingness on the part of Congress to risk its precious political

neck by standing for sound business as opposed to sentimental clamor. We admit there is some popular sentiment in favor of the soldier bonus, but we are inclined to believe that if the question were submitted to popular vote with the understanding that those who cast a ballot in the affirmative were at the same time to drop a \$10 bill in the ballot box, the bonus would rapidly lose support. And yet a contribution of many times \$10 will be levied on every voter if the legislation is passed. Business of the country should make a concerted effort to deter Congress from taking an unwise step, the consequences of which we shall suffer for many years.

Deflation in

Coal-Mining Cost

ANNOUNCEMENT by coal operators of the Pittsburgh district of the wage rates they expect to pay after the termination of the present biennial scale of the United Mine Workers, which runs to April 1 next, furnishes occasion for study of the situation as to deflation of bituminous coal-mining costs.

While it is traditional that it requires two to make a bargain, the probabilities are that the wage scale now proposed will actually be effective without important modification.

For pick mining in the thin vein mines of the Pittsburgh district the proposed rate is 77 cents per net ton of mine-run, against \$1.1164 in the existing scale, a reduction of 31 per cent. That is a moderate reduction, seeing that the high scale has diverted nearly all the business formerly enjoyed by the Pittsburgh district to nearby non-union districts, such as the Connellsville region, where wages have been deflated. The proposed rate is substantially the same as the 77.64-cent rate given the miners April 16, 1917, when the miners displayed an indisposition to work under the 67.64-cent scale signed as of April 1, 1916, for 2 years. The "pre-war" rate may be taken as the 64.64-cent rate obtaining for two biennial periods, April 1, 1912, to April 1, 1916. Back in 1896, when the men were paid on a screened coal basis, to keep down the production of slack, the rate was 54 cents, which by the ratio recognized some time ago would be equal to about 35 cents if the run-of-mine were paid for, as at present. Thus the proposed rate is more than double the rate of a quarter century ago.

Fears that there will be a serious shortage of coal on account of wage disputes by the United Mine Workers are probably unfounded, although there may be a strike with temporary disturbance of supply. These disputes have been very serious in the past. Reference to the large amount of time that has been lost by coal strikes in the 21 years 1899 to 1919 inclusive was made in *CHEMICAL & METALLURGICAL ENGINEERING* Jan. 4, 1922. Conditions now are different, however. One point is that mining suspensions in the past have sometimes been attended by advances in the market price of coal, making feasible the payment of wage rates in dispute, while no such policy would be countenanced now.

While only approximations can be made of the various factors involved, close enough guessing can be done to indicate that the United Mine Workers are not able to produce a mining suspension that would cause anything like an acute shortage of coal. Anthracite may be omitted from the reckoning. In bituminous coal the mining organization has hitherto controlled between 60 and 70 per cent of the mining capacity. The maximum production, 579,385,820 tons, in 1918, was well

under the present capacity, being, say, between 80 and 90 per cent. The current requirements are only 65 or 70 per cent as great. Taking these factors together, it becomes evident that the current requirements could very nearly be supplied by the non-union capacity. It must be considered that some of the non-union capacity does not produce good coal, merely coal that is in demand when coal is very scarce, but it must also be considered that not a few mines have turned non-union recently, because the union scale did not enable the operators to meet the market, and the men wanted to work. And more of this may occur between now and April 1, and immediately after that date. Altogether, it seems fairly certain that there is going to be deflation in the cost of mining coal to something like a reasonable basis comparable with the cost of conducting other industrial enterprises involving the employment of labor. With deflation also in railroad and building trades labor, the country would be in fairly good shape.

Chemical Contribution

To Agricultural Efficiency

THE Congressional commission of agricultural inquiry reported during December on causes of the agricultural crisis, and during the past month there has been a conference in Washington on the agricultural problems of the country at which these same matters have been publicly considered. But in all of the discussions there has been too great a tendency to subordinate or ignore altogether matters of efficiency in agricultural production.

The report of the Congressional commission presented about a dozen recommendations bearing upon co-operative combinations, credit extension, warehouse systems, freight rates, statistics, foreign trade attachés, grading of products, record keeping, better roads, price adjustments, etc. But it said almost nothing about those means which the chemical industries offer to agriculture for increasing production. A somewhat similar neglect of this question occurred in the public conference, though some attention was there given to the question of fertilizers.

Industry as it proceeds to organize itself almost invariably starts first at the point of production to get the maximum attainable efficiency before seeking support for its activities by auxiliary economic factors. In a few branches of agriculture this principle has been partly recognized and the use of fertilizer for increasing the productivity of the land is regularly and widely practiced. As a basic industry upon the welfare of which we all depend, agriculture stands in the first rank. No sound thinker dare ignore all of these economic factors which must be set right for the good of agriculture. But agriculture has a duty of its own in the management of its internal affairs. And the rest of the community may well insist that this responsibility for obtaining maximum productivity from given areas of land with a given expenditure of human labor shall be observed.

Agricultural chemistry has not yet reached the flower of its perfection, nor has the fertilizer industry yet taken advantage of all that chemistry has to offer in order to put it on a scientific basis. A vast amount of educational work has been done, but much remains to be accomplished in increasing the productivity of the soil before we can feel satisfied that economic aids will solve the problems of the farmer. First aid in the form of chemistry has not been sufficiently applied.

Readers' Views and Comments

Omnia Mutantur, Nos et Mutamur in Illis

To the Editor of Chemical & Metallurgical Engineering

SIR:—It was my fortune to be present at the Pittsburgh meeting of the American Chemical Society in 1902, referred to in your editorial of Jan. 18.

The "well-dressed chap" (he *must* have been well dressed if Dr. Baskerville thought so, although his clothes made no such impression on me) was waiting for us when we came out; he had his machine set up and invited some of us to inspect it. It was simply a microscope for observing the Brownian movement and we were excitedly urged to believe that the dancing particles were the atoms themselves. As I recall it, the man's announcement in the meeting was decidedly in the nature of an interruption, being addressed to the auditors generally and not to the chair. Dr. Remsen correctly sized him up as a crank and acted promptly and neatly in heading him off.

Xenia, Ohio.

AUSTIN M. PATTERSON.

Oil-Shale Distillation in Situ in New South Wales

To the Editor of Chemical & Metallurgical Engineering

SIR:—The oil-shale industry of New South Wales is of long standing, having been started in 1865 by a short-lived enterprise which recovered oil from oil shale in the Kembla Valley in the southern coal fields. Following this a company distilled oil shale successfully for some years following 1878 at Hartley Vale, but oil recovery was later eclipsed by export of high-grade shale for gas enrichment, and finally exhaustion of the deposit caused the industry's discontinuance.

About 1905 the Commonwealth Oil Corporation came into existence, and £1,200,000 of capital was raised and expended, but the company has never paid a dividend. In July, 1919, this company entered into an agreement with John Fell, of Sydney, under which he is to operate the property for the joint account of the company and himself for a 10-year period, and at the present time the shale in the Newnes district is being worked under this agreement.

Now comes a report, published in the *Sydney Morning Herald* of Oct. 27, 1921, that Mr. Fell has succeeded in distilling oil from the shale in the Wolgan Valley by setting fire to the oil shale in an old working which has been so protected and confined by brickwork that the combustion can be controlled by regulating the supply of air. It is reported that, after starting the fire on a Monday, on Thursday, when the chamber was tapped, the amount of oil which flowed out exceeded the available storage capacity.

The experiment seems to have great significance for the Australian oil-shale industry, as the costs of mining and retorting the oil shale and of refining the crude oil have exceeded the landed cost of American petroleum products, and the industry has been enabled to survive only through a graduated bonus paid by the commonwealth government on home-produced oil. Other possibilities of gas and power production have been opened up by Mr. Fell's experiment which will be further developed.

It is interesting to note that the idea of gasifying and distilling materials *in situ* is an old one,¹ although this seems to be the first large-scale trial made with promising results. It should be borne in mind that the experiment here reported was carried out with the rich "kerosene shale" of New South Wales, and it is not probable that many of our American shales could be treated by similar methods, even though the principle of distillation *in situ* should prove successful in the commonwealth.

CHARLES L. JONES,

Mellon Institute of Industrial Research, Industrial Fellow.
University of Pittsburgh,
Pittsburgh, Pa.

To Assist Legitimate Users of Industrial Alcohol

To the Editor of Chemical & Metallurgical Engineering

SIR:—Because of the difficulty various manufacturers have experienced in obtaining their requirements of alcohol for industrial purposes the Committee on Industrial Alcohol of the American Chemical Society believes it advisable to call to the attention of manufacturers the fact that there is such a committee and that this committee stands ready to co-operate with them in every possible manner. This service is without any expense to those who require this essential chemical raw material.

During the past several months manufacturers requiring alcohol for legitimate industrial purposes have been experiencing many difficulties. Numerous changes in rules and regulations and the issuance of new ones have caused considerable delay and expense.

The Committee on Industrial Alcohol was appointed at the Rochester meeting of the American Chemical Society. This committee offers its services to the chemical industry to assist in obtaining permits, shipments, etc.

Chemical manufacturers who wish to take advantage of this offer should communicate with the chairman or any member of this committee. Their names and addresses are as follows:

Dr. Martin H. Ittner, chairman, Colgate & Co., Hudson St., Jersey City, N. J.

Dr. Raymond F. Bacon, 50 East 41st St., New York City.

Dr. Charles Baskerville, College of the City of New York, New York City.

Dr. George F. Rosengarten, Powers, Weightman & Rosengarten Co., P. O. Box 1625, Philadelphia, Pa.

Dr. Frank R. Eldred, Eldred & Atkinson, Inc., 48 E. 41st St., New York City.

Dr. Edward Mallinckrodt, Jr., Mallinckrodt Chemical Works, St. Louis, Mo.

Dr. Burnell R. Tunison, secretary, U. S. Industrial Alcohol Co., 27 William St., New York City.

It is believed that publicity to the above statement will be appreciated by manufacturers who may be benefited by the services of the committee.

New York City.

B. R. TUNISON.

¹On "Gasifying Coal at the Mine," see Hamor, *Scientific American* for Nov. 2, 1912. A number of patents have been issued on various schemes for distillation and gasification of various materials *in situ*, among which are U. S. Pat. 1,342,741 to David T. Day, and British Pat. 162,337 (1919) to D. Diver.

The Technical Paper and Its New Relation to Industry*

In Order Better to Fulfill Its Functions of Service and Leadership the Modern Technical Paper
Has Extended Its Scope of Usefulness and Supplemented Its Technology With the
Economics and Business of the Industry It Serves

By H. C. PARMELEE

IF WE ATTEMPT to analyze the elements that have contributed to the evolution of modern civilization in all its variety and complexity, we are likely to come to the conclusion that the most powerful single force has been the rapid development in means of communication among individuals, communities, cities and nations. To such a degree of perfection have these means been developed, and so complete has been their conquest of conditions on our own earth, that intrepid pioneers are already attacking the problem of interworld communication.

Great industries have been founded in the course of these developments. Ships sail the seven seas to the uttermost parts of the earth; railroads cover the continents like networks of steel; aircraft cruise their routes regularly with incredible speed; the telephone and telegraph are known in the humblest village; radio communication is almost a commonplace; and finally the products of the printing press have long since lost the element of novelty and are accepted as an integral part of our daily life. These agencies have brought about the great transition from primitive society in which human intelligence was transmitted by word of mouth. They have at once simplified and complicated modern life; simplified it by bringing the peoples of the earth into closer contact, and complicated it by extending our relationships and increasing our duties and obligations. They have unified nations in war for a great cause, and they have given an impetus to peaceful industrial growth unparalleled in the history of the world.

DEVELOPMENT OF CIVILIZATION DEPENDENT ON PRINTING

But though all these agencies have contributed largely to the development of modern society, it is certain they have not been of equal value and importance. Ships, railroads and aircraft may be developed ever so highly and yet be limited as means of communication if they transport only men from place to place. Important as are the telephone, telegraph and radio in the quick transmission of intelligence to and from all parts of the world, they are still restricted to communication between fixed points and a small number of individuals. Obviously some other agency in combination with these has been responsible for that wide distribution of human knowledge and intelligence that characterizes modern society and which has been responsible for its development. Some other means has been evolved to reproduce for thousands and millions of individuals the product of the world's great intellects and lay it regularly before all who want it. It is in the discovery and perfection of printing and paper that we find the essential element in all this marvelous development. Modern civilization, said Lord Avebury in addressing an inter-

national gathering of paper manufacturers, depends upon the discovery of cheap paper and rapid printing for the wide distribution of information.

This we may accept without demanding exhaustive proof, for it requires no stretch of the imagination to visualize the influence of printing on the wide dissemination of knowledge. By this means industrial, political and economic information has spread with amazing rapidity. By it the intelligence of one nation has become the property of the whole race, and the intellect of a great leader has been able to influence the trend of thought of the entire world. In short, we may accept the press as the means of communication par excellence, and proceed to examine one of its comparatively small but important branches—namely, the industrial press, that has just begun to sense and exercise its power.

GROWTH OF THE INDUSTRIAL PRESS

Industrial publishing has reached its highest development in the United States, where more than 1,200 periodicals are now devoted to industry in all its phases. The growth of this great publishing business has been coincident with the industrial expansion of the country itself. The first industrial paper of which we have record in this country was founded in 1846. In the next decade two more were established, but no great impetus was given to the business until after the Civil War, when the country went through its marvelous period of growth and development. Industries of all kinds invited leadership, and industrial magazines sprang up to point the way. The result was that from one paper in 1846, three in 1856 and twenty-five in 1869, the number grew to 800 by the end of the century and to well over 1,200 at the present time. Including Canada, it is estimated that there are in America between 1,200 and 1,400 industrial publications, the number varying with the method of classification.

An important group of the industrial press comprises what are known as technical papers because they deal with the technology of industry, with the application of science and engineering principles to the problems of production and management. It is in this group that you, as chemists, are most interested; and since both you and I have a still narrower interest in technical magazines devoted to the chemical industry, we may confine further observations to papers of that class.

My topic, "The Technical Paper and Its New Relation to Industry," suggests a contrast with an earlier relation, and so we may go back for a moment and sketch that former relation briefly in order to emphasize the new order that must be expanded and developed if the technical paper is to live up to its opportunity for service and leadership.

Technical papers for the chemical and allied industries are of comparatively recent development in this country, but if we examine the early files of such papers

*An address delivered before the Chicago Section of the American Chemical Society, Nov. 18, 1921.

we will find that they were devoted almost strictly to matters of technical interest. They recorded the results of scientific research and investigation and of progress in the arts. Processes and products were discussed in their scientific and technical aspects. The contributions were of a high order of merit, and the contributors were recognized scientists of learning and ability. On the whole the publication was maintained on a high plane of scholarship and was a credit to the profession. Its reliability and integrity were above reproach and its subscribers bore testimony to its value and influence in all technical matters. It was a tool of the profession rather than of the industry.

The *raison d'être* for such a magazine is not far to seek. It was a product of its time and it served its purpose well. Technical industries were in a state of rapid evolution, and the latest developments in technology were of primary importance. It was essential that the scientific foundation of industry be carefully laid in order that the superstructure might endure. In short, industry being more interested in, and most in need of, technical leadership and guidance, the function of the technical paper was plainly to serve along these lines.

NEW RESPONSIBILITIES FOR THE TECHNICAL PAPER

But excellent as this service was, and adequate though it proved for its time, it will not suffice today. New elements have entered into our national industrial life and by presenting new problems to industry have at the same time laid new and additional responsibilities on the technical paper. It is no longer enough for it to treat of technology; it must consider the business and economic problems of industry as well. The technical paper can no longer fulfill its function if it merely discusses processes and products; it must also be the business exponent and mouthpiece of its industry, reflecting its needs and guarding its interests. It must become an integral part of its industry, serving all its needs. It must be of the industry as well as for it.

The perception of this new responsibility was quickened during and immediately after the war, when we faced industrial and economic problems that far transcended in importance the problems of technology. The Government itself was confronted with industrial problems of the greatest magnitude, and as a result of the war was involved in the most intimate relations with business and industry. There was the greatest need for some public agency to reflect the needs of industry to the Government and to interpret the intentions and acts of the Government to industry. In this condition industry found itself without a mouthpiece or exponent unless the technical press threw itself into the breach, which it promptly did.

Washington became a great center for technical and industrial news, requiring the closest daily contact on the part of the business press; and as a consequence of the early recognition of this fact, industry was served with pertinent Government news through its technical papers.

The necessity for this arose mainly from the fact that the daily press in all its excellence was not equipped to meet the need. It was not and could not be intimately familiar with the details of industry, and consequently could not sense its needs. The whole country was face to face with a brand new crop of problems, and since industry had learned to follow its own technical papers in matters of science and technology, it naturally turned

to the same source for leadership in these new conditions. The technical paper promptly sensed and accepted the situation. It became a magazine of opinion on labor problems, on the tariff, on wages, the cost of living, foreign trade, Government policies, the patent system, revenue legislation and finance and many other matters formerly regarded outside its editorial scope. It discussed industrial waste in all its forms: the necessity for better cost accounting, for greater safety in industry, for improved housing and sanitation, for more skillful management, for more research. It expressed its opinion on the regulation of business by the Federal Trade Commission and the Interstate Commerce Commission. It took up industrial relations between employer and employee and devoted much space to the numerous phases of that many-sided subject. It spoke with authority and competence on such matters as reorganization of Government departments because some of its editors had been drafted from Government service and knew whereof they spoke.

These things were invaluable because they reflected to the industry the opinions of men familiar with the industry itself and sympathetic with its needs. Speaking from a chemical point of view, it was not enough to discuss the technology of the industry; somebody had to present the economics as well. For example, coincident with the technical problem of fixing nitrogen was the question of Government ownership and operation of nitrate plants and its effect on business. Of quite as much importance as how to make dyes was the question of establishing an industry in the face of foreign competition. The tariff was a paramount issue. We had the brains for dyemaking, but we needed the economic basis for an industry without which our technical brains would avail us nothing. The alcohol industry likewise was, and is, much more concerned with fanatical legislation than with methods of manufacture. All of these things were consistently presented in the technical press for the benefit of industry and the education of Government officials.

TECHNICAL PRESS SUPPLIES INDUSTRY WITH VITAL STATISTICS

In the matter of new development there was the constant necessity of keeping the economic and industrial as well as technical aspect clearly in mind. For this reason the technical press has brought to industry vital statistics on consumption and production, on imports and exports. It has shown the close relation of plant location to industrial success. It has featured the importance of markets for new products and sources for raw materials. It has acquainted industry with pertinent activities of the Government, sometimes approving and sometimes condemning.

In its relation to the Government the technical paper has been constructive and helpful. Witness its service since the war in aiding in the disposal of surplus property; in suggesting new uses for materials held in large quantities by Government departments; in discussing the function of the Government in research; in advocating reform in the Patent Office; in supporting the Chemical Warfare Service and creating public sentiment that resulted in establishing this branch of the service on a scale somewhat commensurate with its importance.

Probably the greatest stimulus to this new function of the technical press as an intermediary or connecting link between the Government and industry was the action of Mr. Hoover inviting the editors of the business

press of the country to assist him in solving many of the problems with which he was confronted in the Department of Commerce. This was at once the greatest recognition of the importance of the industrial press and a challenge to prove its usefulness by showing its intimate knowledge of industrial matters. What body of men in the country should be better able to reflect to the Government the needs of industry, and carry to industry the story of the Government's intention to aid and assist rather than hamper and restrict? So argued Mr. Hoover, and accordingly the memorable Hoover editorial conferences began in Washington last spring.

TECHNICAL PRESS AS AN AID TO GOVERNMENT

They have resulted in laying before the Secretary of Commerce plans for elimination of waste, for standardization of sizes, types and styles of industrial products, for correlating the bureaus and agencies in his department and making them function more directly for the benefit of industry. They have resulted in the first effort ever made in this country to publish monthly vital statistics on consumption, production and stocks of critical commodities in the basic industries. Finally, they have been helpful in the reorganization of the Department of Commerce by finding men from the industries to head the new commodity divisions that have been created. And all of these things, mark you, have been done by technical industrial papers that formerly devoted themselves wholly to matters of science and technology, because they have seen clearly the need of this new service to their respective industries. Much of the best work has been done quietly through committees, questionnaires and researches, but it has been none the less effective. Mr. Hoover has generously recognized the value of this service in a message to the editors in which he said in part:

The editors of the business press have shown a fine spirit of service. Your opportunity for leadership is unique and unchallenged. Upon you rests in large measure the responsibility of the control of industrial thought and opinion in the detail of the industrial, economic and technical problems which confront us.

I have mentioned the inadequacy of the daily press in presenting to industry such matters as have just been discussed. They are essentially technical and hence not within the grasp nor the province of the daily newspaper. They will not be adequately presented for business and industry except through the medium of the industrial press. This is no reflection on the daily press, but merely a recognition of its limitations and the consequent need for the industrial press. We may consider a few examples.

EXAMPLES OF TECHNICAL NEWS SERVICE

As an industrial disaster the explosion of the nitrate plant at Oppau, Germany, was of such magnitude as to interest the entire world. And due to its marvelous mechanism for transmitting intelligence, the daily press gave us immediate reports of the occurrence. But the explosion had a far greater and deeper significance to chemical industry, and in all its attempts to give precise information that might be helpful the daily press failed utterly due to its manifest limitations. Not only did it fail as a purveyor of precise, accurate and reliable news of the event, but it exemplified the blind as leaders of the blind in its editorial comment. So great a newspaper as the *New York Times* drew the conclusion that German chemists had been experimenting with new and deadly gases, in violation of the terms of the treaty, and

had wrought their own destruction through their discoveries. It called upon the Badische company to show clean hands in the matter, and it looked frankly with suspicion on the whole affair. Mystery surrounded the explosion and consequently mysterious conclusions were drawn as to its cause and significance. The press dispatches having said that the disaster was due to "the decomposition and subsequent explosion of a large quantity of ammonia and sulphate of saltpeter," the *Times* suspected "experimenting of a secret nature," and thought it "not inconceivable that the disaster at Oppau may have been due to covert experimenting by those chemists." All of which was of no help or consequence to the chemical industry, and it devolved upon the technical press through its enterprise and intelligence to inform the industry of the facts as nearly as they could be ascertained.

Examples might be multiplied. Chemical warfare was first condemned in the daily press, and first supported by the technical paper. Reports of such conventions as President Wilson's first industrial conference and the recent unemployment conference were more reliable and pertinent in the industrial than in the daily press, for the reason that the latter was inclined to feature spectacular incidents and subordinate substantial accomplishments.

All of these things are in the nature of a service to industry and the public welfare now performed by the technical press. It is not spectacular, but far-reaching. It influences the intelligent leaders of industry to blaze the way to new reforms, initiate constructive policies and establish sound principles and practices in industry.

This service to industry by the technical press is a leaven that eventually leavens the whole of society. Through the leadership of the technical magazine in its own industry, it spreads information and serves as a clearing house for new ideas that eventually are translated into economies for the benefit of society as a whole. The service to industry is direct, and to society indirect.

FUNCTIONS AND STANDARDS OF THE TECHNICAL PRESS

From this general portrayal of the activities of the modern technical paper we may proceed to summarize its functions in industry and study the mechanism through which they are performed.

1. The modern technical paper is still a magazine of information pertinent to the technology of the industry it serves. This is an important function that cannot be subordinated without jeopardizing industrial progress. Economies resulting in cheaper production must still be worked out through scientific research and the application of the results in the factory. But this is not service enough.

2. The modern technical paper also treats of the economics of its industry, informing its readers on the relation of the tariff, finance and other legislation to business.

3. It is the newspaper of its industry, gathering weekly the items of personal and business intelligence on which its readers should be informed. Market movements and trade tendencies are reflected in reports gathered at first hand. Foreign as well as domestic news is obtained regularly by cable and wire.

4. The modern independent technical paper is a magazine of opinion—the mouthpiece of its industry. And herein lies one of the distinctive differences be-

tween it and the technical society magazine. The editorial independence of the industrial paper, its freedom from domination by any interest or allegiance to any group, make it possible to adopt policies in the interest of the industry as a whole. Obviously this is denied to the society publication, which must serve primarily its own membership. Editorial opinion cannot be expressed with freedom on a wide variety of topics for the evident reason that the magazine must speak for the society. An independent industrial technical paper, on the other hand, labors under no such handicaps, being bound only to serve the best interests of its industry whether people agree with it or not. If subscribers do not like its policy they need not take the paper.

5. The modern technical paper sets a high standard of business ethics and practice in its industry. Both in its business and editorial departments it subscribes to a code of ethics that has been adopted by associations of business publishers and industrial editors. These standards are high and must be subscribed and adhered to by members of the association.

ENFORCING ITS CODE OF ETHICS

The technical editor is pledged to consider first the interest of his subscriber. Truth and honesty must characterize his every activity. He is obligated to present the news of the industry free from personal bias and to determine the editorial contents of his paper independently of advertising considerations. The publisher also sets a high standard of business practice in the acceptance or rejection of advertising and in publicity regarding the character and extent of his circulation.

Periodical investigations are made to see that members are living up to these standards. This is one of the most powerful factors in making the technical paper a leader in its industry. With its own skirts clean it can consistently demand that its industry be free from unfair practices. Having adopted a high code of business ethics for itself, it can, both by precept and example, urge similar action upon its industry. The adoption of a code of editorial ethics and business practice has been of the greatest benefit in establishing the independence of the technical paper.

RECOGNITION AS AN ESSENTIAL ELEMENT OF INDUSTRY

The exercise of all these functions results in a service, first to industry and then to society, that makes the modern technical paper an essential element of industry. It was so regarded by the Government during the war; and it must be self-evident that in times of peace publication of knowledge and intelligence is indispensable to the development of industrial literature. What then is the mechanism for exercising these functions? The answer is found in the editorial staff. And just as the technical paper's new relation to industry requires a broader service, so the modern editorial staff comprises a wider range of talent. In many respects it resembles a college faculty, being composed of men who are specialists in their respective branches of technology and industry. Papers covering the chemical and allied technical industries find it particularly necessary to have comparatively large staffs of qualified scientists, technologists, economists and industrial experts. They are called upon to judge the competence of articles that form our technical literature. They are expected to reflect sound opinion on matters of public policy in relation to

their industries, and to take the lead in safeguarding those industries from ill-advised legislation or private practice. They must display enterprise and initiative in discovering sources of news and information so that their industries may be kept abreast of development. And it goes without saying that in addition to their ability they must be men of integrity with a keen sense of editorial ethics.

EDITORS MUST MAINTAIN CLOSE CONTACT WITH THEIR INDUSTRIES

Nor can these things be accomplished without close personal contact with the industry itself. Travel by the editors is a *sine qua non* of successful industrial journalism. Conventions must be covered and reported in their essential features, for hundreds and thousands of men are unable to attend and must rely on the published record for their information. That this service is appreciated is attested by the correspondence following the publication of convention proceedings, asking for more detail or further information. Plants must be visited and processes described in order that text book fundamentals may be amplified and brought up to date with practical details of current practice. In short, the modern technical paper cannot be edited from the desk, but it must show a familiarity with industry itself that is acquired only by personal contact. The consequence is that the industrial editor is enabled to see his industry as a whole and judge it impartially. This was strikingly exemplified at the last National Conference of Business Paper Editors in Chicago, when a résumé of conditions in ten basic industries was presented by as many editors of industrial magazines. These reviews were authoritative and could not have been pictured better, if as well, by industrial leaders themselves.

RELATIONS TO THE INDUSTRY AND TO THE INDIVIDUAL

Such, then, is the new relation of the technical paper to industry as seen by the technical editor. Such is the duty of the industrial and technical press, as well as its opportunity for service, as conceived by the publishers. It results in a service that is growing more and more expensive, but which yields results to industry that more than justify publishers' outlay. No single industrial unit could afford to maintain for itself the service thus rendered to industry at large. It is a service that is destined to be expanded rather than contracted, just as industry itself becomes more complex and needs broader vision and leadership.

This evolution holds its lesson also for the individual. Just as the technical paper must supplement its technology with the economics and business of industry, so must the individual broaden his scope in order to find his greatest usefulness. Science will never develop its greatest usefulness to society as long as it is translated into technology only. It must find expression also in sociology, in economics and in the management of industry. This will call for broader training and more diverse talents among scientists, some of whom will continue to enrich the records of research while others develop managerial ability or technical superiority or acquire skill in the practical application of economics and sociology. The ultimate aim—for the individual as well as for the industrial press—will be the perfection of our industrial processes, the elimination of waste, the stabilizing of labor and production, so that human happiness and standards of living may be increased. To such an end the modern technical paper is dedicated.

Colloidal State in Metals and Alloys. IV—Iron and Steel

Atomic Dispersion of Carbon in Austenite Is Unlikely, but Martensite, Troostite, Sorbite and Pearlite Contain Carbide Particles of Increasing Size—Martensite and Other Dispersions of Critical Size Are Hard Because of Enormous Surface Tensions Associated With Fine Grain*

BY JEROME ALEXANDER

President, Uniform Adhesive Co., Brooklyn, N. Y.

THE enormous literature that exists regarding the iron-carbon alloys exhibits at once their great importance and exceeding complexity, and within the brief limits of this paper only a few of the most striking facts can be dealt with. Since the behavior of the iron-carbon alloys is greatly influenced by the allotropic changes of iron itself, it will perhaps be best, first, to consider what these are, according to the evidence available.

ALLOTROPY OF IRON

After freezing at about 1,505 deg. C., pure iron, upon further cooling, shows a large evolution of heat at about 900 deg., known as the thermal arrest point A_r , and a smaller evolution of heat at about 780 deg., known as the thermal arrest point A_c . It is generally accepted as a fact that above 900 deg. the iron exists in the γ form, which is non-magnetic, and below 780 deg. in another allotropic α form, which is magnetic and exhibits a different crystallization from γ iron. Rosenhain believes¹ that the weight of evidence shows that between 900 and 780 deg. the iron exists in a third allotropic form, known as β iron, which has the same crystal form as α iron, but resembles γ iron in being non-magnetic. Benedicks,² on the other hand, believes that the evolution of heat at 780 deg. indicates, not a transformation of a β allotrope into α iron, but the final disappearance of persistent γ iron molecules from the metal.

Considering the recent work on the allotropism of sulphur, it seems that these apparently conflicting views can be reconciled by regarding the iron between these temperatures (900 and 780 deg) as an allocolloid or allodispersoid, the so-called " β iron" being an α - γ adsorption compound (α iron dispersed in γ iron), whose break-up into the more completely oriented α iron sets free the relatively smaller amount of heat at the point A_r . This view accounts for the following facts: (1) that " β iron" has the same crystal form as its "dominant partner," α iron, but, unlike it, is not magnetic—for magnetism seems to depend upon a peculiar regular molecular orientation³; (2) that γ iron dissolves iron carbide, whereas " β iron" and α iron do not; for whatever γ iron exists in the β zone is adsorbed by or in some kind of loose combination with the dominant α iron and is not free to exert its solvent power on iron

carbide; (3) that an increase in strength is noted when α iron is transformed into " β iron"; for the formation of some γ iron by increase of temperature over about 780 deg. results in the formation of the α - γ adsorption compound, which increases the free surface and strength of the system; (4) that the structure of " β iron" is finely acicular, indicative of crystallization in the presence of a colloid.

DOES AUSTENITE CONTAIN MOLECULAR CARBON OR CEMENTITE?

Leaving this moot question, however, let us consider the behavior as noted in the equilibrium diagram, Fig. 1, of a low-carbon steel, containing, say, 0.2 per cent of carbon, which dissolves in the liquid iron as Fe_3C . From freezing down to 840 deg. this steel consists of an apparently homogeneous "solid solution" or dispersion of iron carbide or cementite in γ iron.

[In a recent paper⁴ entitled "The Slip Interference Theory of the Hardening of Metals" Jeffries and Archer state:

"There is good reason to believe, however, that in all cases solid solutions are characterized by the atomic dispersion of their components." This is true only if the expression "solid solution" is limited to such dispersions; but most solid solutions contain aggregates, just as do many or even most ordinary solutions, especially if concentrated. Jeffries and Archer further state that "the carbon in austenite is present as individual atoms of carbon"; that "these atoms are undoubtedly held strongly to the neighboring iron atoms, but the union is not permanent. Diffusion must consist in a migration of carbon atoms and not of groups or 'molecules' containing several iron atoms. Such groups could not, on account of their size, diffuse through solid iron."

It seems to the present writer that there is no good reason to doubt the existence of Fe_3C , especially when the steel is semi-solid or solid. For there exists a condition of kinetic or dynamic equilibrium in which this compound is being continually formed and broken up, so that while a certain per cent of free carbon atoms may exist at any one moment, there is probably an enormously larger percentage of Fe_3C . Viewed from the standpoint of a kinetic equilibrium, all difficulty regarding the diffusion of Fe_3C disappear.⁵

With large amounts of carbon, as in cast irons, much of the C is thrown out on cooling and forms graphite, or under conditions of quick cooling or high pressure may form diamonds, as Moissan has shown.]

At any rate, at 840 deg. C. (A_r), the "solid solution" transforms into an α - γ dispersion (" β iron"), and at 750 deg. C. (A_c), the residual α - γ adsorption compound decomposes into α iron, the steel now consisting of α iron crystals dispersed in a "solid solution" of iron carbide in γ iron. With further cooling, the quantity of α iron crystals increases, until at a little below 700 deg.

The present series of papers was written mainly in the fall of 1919. Reduced to about half their original form, they were read before the Columbus meeting of the American Institute of Mining and Metallurgical Engineers, October, 1920, and will so appear in vol. 64 of its *Proceedings*. They are now given in full, together with some recent additions which are indicated by enclosure within square brackets [].

*Part I, on Molten Metal, appeared in *CHEMICAL & METALLURGICAL ENGINEERING*, vol. 26, p. 54; Part II, on Crystallization, in vol. 26, p. 119; Part III, on White Metal and Brass, in vol. 26, p. 170.

¹"Introduction to Physical Metallurgy," p. 170.

²*Iron and Steel Inst.*, No. 2, 1912.

³The so-called Haeussler alloys are magnetic, although their constituents individually are not.

⁴*MET. & CHEM. ENG.*, vol. 24, p. 1059.

⁵See also p. 1055 of Jeffries and Archer's paper.

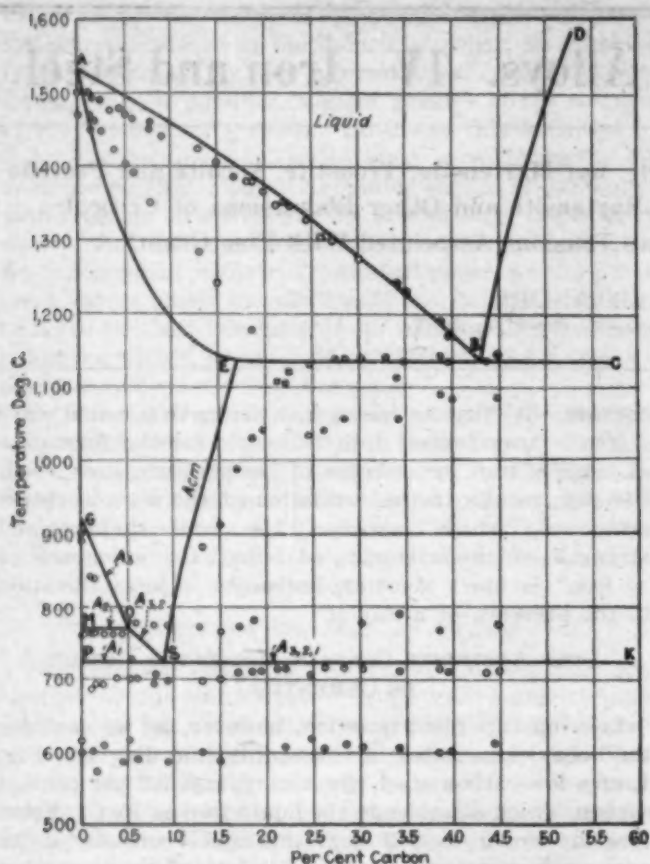


FIG. 1. EQUILIBRIUM DIAGRAM OF THE IRON-CARBON SYSTEM (AFTER HOWE. POINTS FROM CARPENTER AND KEELING)

C. (Ar_1), the remaining γ iron-carbide solid solution is transformed into a eutectoid mixture of α iron (ferrite) and iron carbide (cementite), with an evolution of heat.

REACTIONS AT 690 DEG. C.

This last transformation seems to be the break-up of an adsorption compound between γ iron and iron carbide, the former transforming into α iron and the latter being set free to form aggregations of its own. This adsorption compound is the cause of the carrying over of some of the γ iron through the so-called " β iron" zone to the eutectoid point, where, with increasing carbon content, increasing quantities of heat are evolved, the allotropic transformation of the iron itself becoming practically negligible after the steel contains about 0.5 per cent carbon (equal to about 7.5 per cent Fe_3C). In fact, steel of "eutectoid composition" (about 0.9 per cent C, or about 13.5 per cent Fe_3C) exhibits only a single thermal arrest point, at which it glows visibly.

This phenomenon is known as "recalcescence"; it is indicative of a sudden large release of energy consequent upon the breakdown of the extensive metastable system built up of γ iron and cementite, two delayed transformations occurring simultaneously—the iron transforms from γ into α and at the same time the released cementite aggregates. The inhibition of the allotropic iron transformation shows that in eutectoid steel the large percentage of Fe_3C has carried over practically all the γ iron in metastable condition to the eutectoid point. The presence of such elements as silicon and manganese will perceptibly change the location of the eutectoid point, a fact which fits in with the easy disturbance of colloidal systems by foreign substances or "impurities."

But whether this view is accepted or whether the charge is regarded as a separation of carbide from " γ iron solid solution," one thing is certain—there is suddenly released from some kind of solution or combination Fe_3C , an insoluble substance possessing considerable cohesion, which promptly causes it to attempt to aggregate against the interference offered by the now highly viscous iron. This is an ideal condition for the development of a colloidal system; but the cohesive power of the cementite is so great that in unquenched steel it usually appears as shown in Fig. 2b, interspersed with α iron, or ferrite, as fine plates or fibrils, yielding the finely laminated structure known as "pearlite" because under proper illumination it exhibits the iridescent luster of mother of pearl. This iridescence, reminding one of that of a diffraction grating, is evidence of the fineness of the pearlitic structure, which, like Pleuro-sigma, taxes the highest powers of the microscope for its successful resolution, the lamellae being often less than 0.2μ apart.

DIVORCE OF CEMENTITE

As shown microscopically in Fig. 2, after Rawdon, eutectoid steel (approximately 0.9 per cent of C) when slowly cooled consists entirely of pearlite, thus corresponding to the pure eutectic of ordinary alloys.⁷ But with very slowly cooled steel, or with steel reheated for a long time at about 900 deg., the cementite tends to group up still further into balls or globules, the liberated ferrite forming larger crystals at the same time (Fig. 2d).

The cementite when present as isolated balls or lumps is of very little use to the steel, which then possesses merely the properties of pure ferrite having a coarse structure—these, of course, being far from equal to those of a mild

⁷In the presence of protective colloids, insoluble salts (i.e., CaCO_3) become more soluble in water.
⁸Rosenhain, "Introduction to Physical Metallurgy," p. 175.

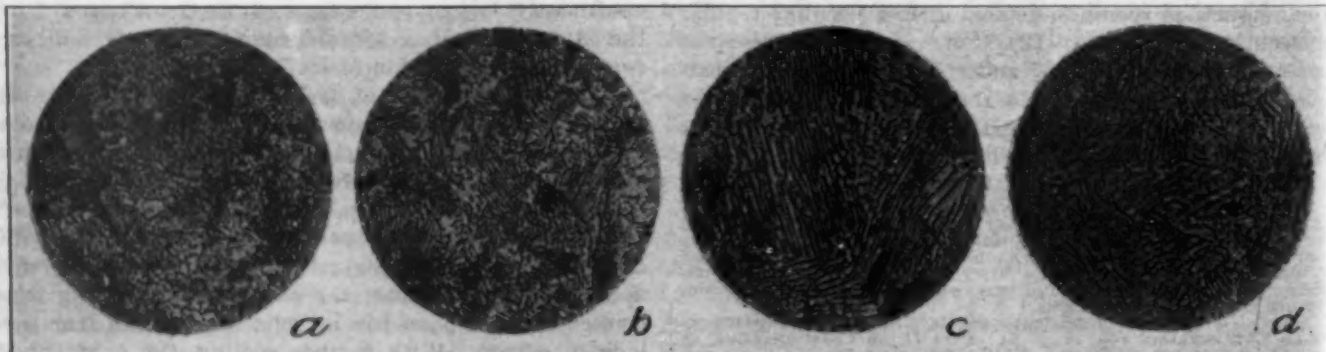


FIG. 2. MICROSTRUCTURE OF 0.85 C STEEL, HEATED TO 800 DEG. C. AND COOLED AT DIFFERENT RATES. $\times 500$
ETCHED IN 5 PER CENT PICRIC ACID IN ALCOHOL

a—Cooled in air. b—Cooled in lime. c—Cooled in furnace. d—Cooled much slower in furnace.

steel having the correct structure. . . . When in the condition of pearlite or sorbite, where cementite is intimately associated with layers of ductile ferrite, the inherent brittleness of cementite is largely neutralized, and the hardness of the duplex constituent—pearlite—is well adjusted to stiffen and support the ferrite matrix of a mild steel. Cementite of itself, however, is not only excessively hard and brittle, as compared with ferrite, but it is also too small in quantity and bulk to serve as an efficient stiffener. Its presence in the isolated state thus becomes a source of weakness rather than strength. The behavior, both under test and in service, of steels having this "free cementite" structure is now well recognized as most unsatisfactory. (Rosenhain, p. 278.)

Quenched or quickly cooled steels, on the other hand, exhibit an entirely different set of microscopic pictures and mechanical properties from slowly cooled steel, which vary with the speed of chilling. Arranged in order of their formation on progressive cooling, the following constituent forms of the iron-iron carbide dispersion are recognized by metallurgists:

NATURE OF STRUCTURES IN HARDENED STEEL

Austenite. White, apparently structureless γ iron solid solution, when preserved as such down to ordinary temperatures, either as the result of quenching or by the presence of a third alloying element inhibiting its decomposition—i.e., manganese in manganese steels.

Martensite. The first stage in the aggregation of the γ iron solid solution; the hardest constituent of hardened steels; it varies widely in the details of its structure, but is mainly acicular (Fig. 3).

When steel has been quenched from very high temperatures, the martensite is found to occur in large grains showing a rather coarse acicular structure. When, on the other hand, a steel of eutectoid composition is quenched at a temperature just above the critical point A_1 , then the structure of the resulting martensite is exceedingly fine—so fine, indeed, that some workers, not perhaps provided with the best of microscopic appliances or employing unsatisfactory etching methods, have failed to detect the acicular structure, and have claimed that the best hardened steel contains a structureless "martensite," which they have sometimes distinguished by the term "hardenite"—a purely local term whose general use is not to be recommended. The careful examination of samples of the best and most carefully hardened steels, however, has convinced both the author [Rosenhain] and the majority of impartial observers that martensite can always be shown to have an acicular structure, although in "properly hardened" steel that structure is exceedingly minute. (Rosenhain, p. 179.)

Troostite. A dark-etching constituent (Fig. 3) with characteristic rounded or woolly outlines, found particularly in hypoeutectoid steels at the edges of martensite grains, especially where they border on ferrite. By a suitable rate of cooling, or by proper tempering, martensite can be entirely converted into troostite.

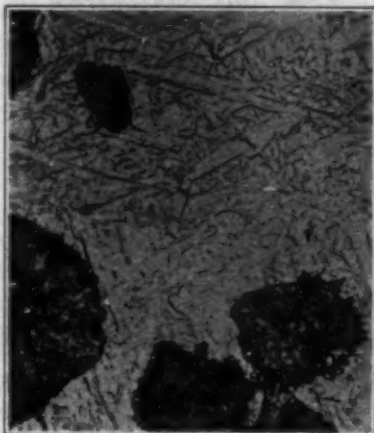


FIG. 3. MARTENSITE (LIGHT) AND TROOSTITE (DARK). AFTER HANEMANN. $\times 450$

It is sufficient for our present purpose to regard troostite as a further step in the degradation of austenite into ferrite plus pearlite. The dark color appears to be due to the condition of the carbon in this stage; the separation of the dissolved carbide from the iron must have begun as soon as the first particles of γ iron be-

came transformed into the β or α condition. In the martensite stage the separation makes itself felt only very slightly by the small difference of color between the various systems of interlacing needles. When the troostite stage is reached we are probably dealing with a material in which the separated iron carbide is present in slightly larger masses. According to Benedicks, the carbide in troostite is present as a colloidal suspension, and it is quite probable that troostite differs from martensite only by the slightly greater segregation of the carbide particles. (Rosenhain, p. 183.)

In the paper by Benedicks cited by Rosenhain, the Swedish scientist remarks:

After studying some of the colloid literature, it was entirely clear to me as far back as 1905 that the nature of troostite is simply explained; it is a solid colloidal "solution" of cementite in iron (a solid cementite ferrosol). In other words, troostite may be conceived of as a highly dispersed intermediate between martensite, the true solid solution, and pearlite, the coagulum. . . . Troostite is a pearlite in which the constituent particles are ultramicroscopically small.

With steel containing 1 per cent carbon, Benedicks obtained the following results, the test-pieces being cylinders 50 mm. long \times 6.5 mm. in diameter:

Temperature, of Steel, Deg. C.	Time of Cooling to 100 Deg. C. Seconds	Result of Microscopic Examination
950	3.07	Only martensite
848	4.32	Only martensite
750	4.11	Only martensite
715	5.33	Martensite with traces of troostite
695	6.2	Martensite with traces of troostite
725	9.5	All troostite

The last specimen had been wound with 1 mm. iron wire so that its weight was increased from 12.3 to 27.5 g., thus lengthening the cooling period. From this it is evident that the speed of aggregation is so great that within a few seconds all the martensite may be transformed into troostite.

SORBITE

When the rate of cooling is further lessened or the temperature of reheating or tempering is further increased, the steel is permitted to progress somewhat further toward the final state of ferrite plus cementite. Instead of the troostite described above, we find a constituent still devoid of any visible detailed structure under the highest available magnifications (Fig. 2a), but not etching to such a deep color as troostite and without the peculiar rounded outlines. This is often called "sorbite," but it may be regarded as simply a variety of pearlite in which the two constituents are so finely divided that they cannot be microscopically separated. The dividing line between pearlite and sorbite, indeed, is simply a question of microscopic resolving power. (Rosenhain, pp. 182, 184.)

Pearlite. This microscopically resolvable dispersion of Fe_3C in ferrite has been previously dealt with.

Before discussing the facts above stated it will be convenient to tabulate the main features:

TABLE I. NATURE OF STRUCTURES IN HEAT-TREATED STEEL.

Iron-Cementite Dispersions	Nature of Dispersion	Crystal Structure
Austenite	"Solid solution"	Structureless streaks.
Hardenite	Colloidal	Structureless martensite.
Martensite	Colloidal	Generally acicular; varies, may be very fine. (Fig. 3.)
Troostite	Coagulation begun	Rounded or woolly (globulitic), Fig. 3.
Sorbite	Coagulum	Fine pearlite, not microscopically resolvable. (Fig. 2a.)
Pearlite	Coagulum	Laminated; may segregate into balls. (Fig. 2.)

Fig. 4, taken from Prof. H. C. H. Carpenter's paper on "The Hardening of Steel,"¹¹ shows graphically the

¹¹J. Iron and Steel Inst., No. 2, 1912; Koll. Zeit., vol. 7, p. 290 (1910).

¹²As will be seen later, in troostite the cementite particles have already grown almost or quite beyond the colloidal stage. In martensite, however, some of the carbide is so fine that the carbon released by the action of acid is reduced by the nascent hydrogen, forming a variety of hydrocarbons.

¹³Engineering, vol. 107, p. 341 (March 14, 1919).

¹⁴The higher the temperature before quenching, the longer the cooling time, and therefore the greater the degree of aggregation.

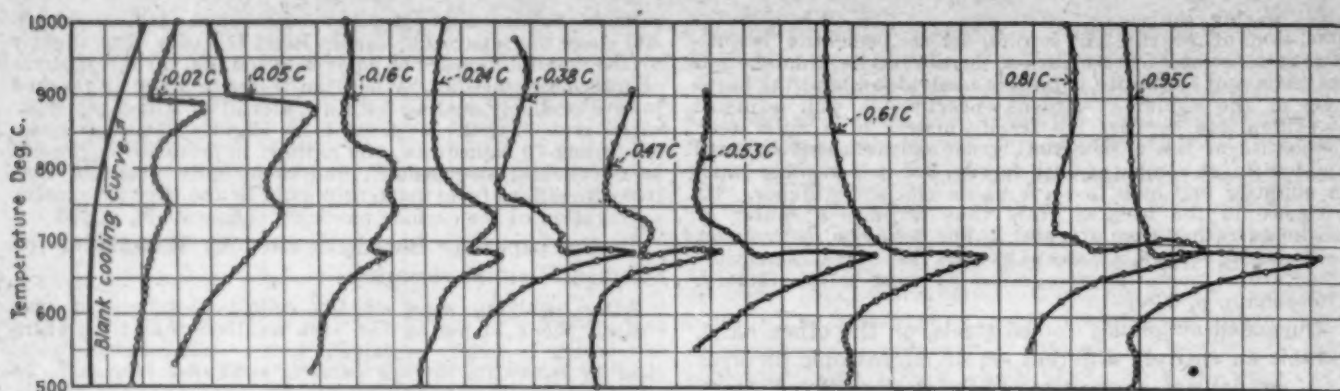


FIG. 4. COOLING CURVES OF IRON AND IRON CARBON ALLOYS

changes in the thermal arrest points in steel with gradually increasing carbon content, the point Ar_1 , appearing at about 0.16 per cent C, and growing, while Ar_2 and Ar_3 diminish, until in eutectoid steel they have disappeared.

Granting that in austenite the cementite is in true molecular dispersion, which I consider very doubtful especially after solidification has begun, it seems evident that, of the remaining members of the iron-cementite dispersion systems, martensite and troostite are to be regarded as within or approaching the colloidal zone of dispersion, whereas sorbite and pearlite are coagula of the pre-existent colloidal systems, the latter visibly so. In the colloidal systems martensite and troostite,

by various reagents are artifacts, from which the original detail of the unetched metal must be inferred."

VARIATIONS IN DISPERSIONS

Although theoretically there is no sharp line of demarcation between any of the members of the iron-cementite dispersion series, the sorbite-pearlite group shows the characteristics of coagulated colloids or gels, as opposed to the martensite-troostite group which represents higher dispersion, with troostite already appreciably on the road to coagulation. With milk, upon great dilution, the gradual aggregation of the actively moving ultramicroscopic particles of the casein sol may be watched in detail over a period of half an hour or more.¹² The ultramicros first form occasional groups of two ("diplococci") and then larger and more numerous groups, until finally the whole casein lies quiet on the slide in large grape-like masses of curd, which under dark field illumination show the reticulated structure characteristic of such gels, and remind one forcibly of very fine martensite (Fig. 5), which, however, usually registers the high crystallization tendency present in its

constituents, but absent in casein. The positive inhibition of the coagulation of the casein by "protectors" (gelatin, gum arabic, sodium citrate) may also be visually demonstrated. With clays, too, similar differences in aggregation may be noticed,¹³ especially "diplococci" and the reticulated structure. But with metals, owing to the dense concentration of their particles, the rapidity of the changes and the high temperatures at which they occur and the practical impossibility of obtaining



VERY FINE MARTENSITE IN
QUENCHED MEDIUM STEEL.
X 500. (RAWDON)

transparent sections" without disturbing the *status quo*, it will probably be impossible to settle moot points with

TABLE II. CONDITION OF STEEL AT VARIOUS TEMPERATURES

Pure Iron	0.2 per Cent Steel	0.9 per Cent Steel
γ Iron.....	γ Iron-cementite solid solution.	This is eutectoid steel. So much cementite is present that no α - γ adsorption compound is formed, the γ iron being held in metastable condition by the cementite, down to Ar_1 .
900 deg. C. γ iron forms α - γ adsorption compound (β iron). Largest thermal point. (Ar_3)	840 deg. C. α - γ compound or β iron forms late because of cementite. (Ar_3)	
Allocolloidal Zone	750 deg. C. α - γ compound (β iron) changes to α iron. (Ar_2)	
780 deg. C. α - γ compound (β iron) decomposes into α iron. (Ar_1)	700 deg. C. γ iron-cementite "adsorption" compound decomposes, γ iron changes to α iron, and cementite is liberated and aggregates. (Ar_1)	700 deg. C. Sudden change of all the iron from γ to α , with liberation of all the cementite. (Ar_1)
α Iron.	α iron and cementite.	Pearlite.

cementite (Fe_3C) is the dispersed phase and iron the dispersing phase; for this is shown by the nature of the pearlite coagulum, which consists of cementite interspersed in ferrite. In martensite, crystal formation is only incipient, inhibited by the high viscosity of the dispersing medium, and perhaps also by the adsorption of a small residual quantity of γ iron (consequent upon lag in its transformation), or of impurities. With troostite the globulitic stage is reached, often found in crystallization inhibited by colloids, and reminding one somewhat of the "clumping" of typhoid bacteria in the Widal test. It must be remembered that metal surfaces etched

¹²See Bechhold, "Colloids in Biology and Medicine," Chap. XXIII, translation by J. G. M. Bullowa. D. Van Nostrand & Co., 1918.

¹³J. Alexander, *J. Soc. Chem. Ind.*, loc. cit. (1909); Alexander and Bullowa, *J. Am. Med. Assoc.*, vol. 55, pp. 1196-1198 (1910).

¹⁴J. Alexander, *J. Am. Ceram. Soc.* (1920), "Ultramicroscopic Examination of Some Clays."

¹⁵Faraday and Bellby did this by floating gold leaf on cyanide solutions. *J. Soc. Chem. Ind.* (1903).

the ultramicroscope alone. Perhaps, as before indicated, the X-ray spectroscopy will aid, small pieces or drops of fluid metal being drastically quenched in liquid air or other liquid gas; or an ultramicroscopic examination of gold, silver or other metal leaf or mirrors, or of films of mercury or amalgams; or the solution of metal by a differential solvent, in the presence of a "protector."

[Jeffries and Archer¹² report preliminary results with the X-ray spectrometer as follows:

(1) Non-magnetic steels show face-centered cubic lattices (γ iron).

(2) Magnetic steels show body-centered lattices (α iron).

"A 1.5 per cent C steel quenched from above the critical in iced brine showed both martensite and austenite under the microscope, and the X-ray spectrometer pattern showed both face- and body-centered lattices. A 0.35 per cent C steel quenched from above A_c , showed only martensite under the microscope and only a body-centered lattice with the X-ray spectrometer." These results confirm the views above expressed, and, as the authors state, they indicate that the transformation from austenite to martensite represents a substantially complete change from γ to α iron. They further show that quick chilling may save some of the iron in γ form. As Benedicks' work¹³ shows, the speed of transformation is very rapid, so that only by the drastic chilling of small specimens as above suggested will much of the γ iron be maintained. Interesting results can be obtained, no doubt, with low melting point metals like mercury, gallium, and with Wood's and Rose's alloys, by quick chilling in liquid air, CO_2 or N, being followed by X-ray examination while cold.]

HYDROCARBONS FORMED ON DISSOLVING MARTENSITE

Meanwhile there is other distinct evidence of the colloidal nature of the cementite in hardened steel. Prof. H. C. H. Carpenter, speaking first of annealed or slowly cooled steel, says:¹⁴

This carbide can be separated from the steel by appropriate solvents which remove the iron. On the other hand, it is not possible to separate any carbide of iron from a properly quenched tool steel. When the latter is treated with dilute acids, the steel dissolves without residue and liberates a complicated mixture of hydrocarbons, both liquid and gaseous. There is, therefore, a fundamental difference in the form of the carbide in a quenched as compared with an annealed steel. In the former it is wholly dissolved, in the latter wholly segregated.

This last statement is too dogmatic, and Prof. Carpenter, evidently appreciating the truth of the adage quoted by Ramsay, *Natura nihil fit per saltum*, retrieves it by continuing:

When hardened steel is softened by annealing, the carbide of iron is gradually precipitated. If the annealing be carried out at low temperatures it is precipitated in the form of ultramicroscopic particles which are known as troostite. On raising the temperature the troostite passes into another variety known as sorbite, and at still higher temperatures well-segregated pearlite results. The gradual tempering and softening of hardened steel is caused by the precipitation of iron carbide in these forms, together with the soft α iron, and as to this no difference of opinion exists.

The formation of hydrocarbons upon the solution of hardened steel in acid shows that the particles of Fe_3C are so small that upon their decomposition the nascent hydrogen is able to combine with the liberated carbon, which must appear in particles approximating molecular dimensions and within the range of molecular attraction. The variety of hydrocarbons formed is evidence of the great diversity in the size of the carbide groups rather than of the existence of a number of different carbides, or "chemical compounds"—in other words, the carbide in properly hardened tool steel exists almost entirely in colloidal form. Great chemical activity is generally consequent upon colloidal dispersion—thus Raffo and Pierni showed that, while fine precipi-

tated sulphur does not affect silver salts in the cold, and does so only partly upon boiling, colloidal sulphur reduces them energetically even at ordinary temperatures. Fine lead, produced by heating dry lead tartrate in a tube, takes fire instantly in the air, as does the phosphorus left upon the evaporation of the solvent CS_2 , or ether.

COLLOIDS PREVENT TREE-LIKE CRYSTALS

The strong tendency of metals to form adsorption compounds, especially when their molecules are aggregating, and the ease with which their crystallization forces may then be controlled are readily shown by a simple experiment.¹⁵ A solution of lead nitrate is divided between two glasses, to one of which is added a "protector" (gelatin or gum arabic solution). On introducing into each glass a strip of metallic zinc, the pure nitrate solution promptly develops large glistering crystals of metallic lead—the well-known "lead tree"—whereas the protected solution yields an amorphous looking black deposit, which microscopic exami-

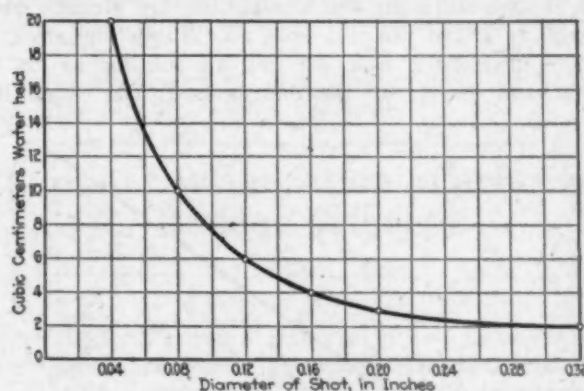


FIG. 6. RELATION BETWEEN DIAMETER OF SHOT AND VOIDS

nation shows to consist mainly of aborted crystals, dendrites and globulites. The characteristic dendritic crystals of lead have elongated arms or processes, which in an interlocked mass may easily be mistaken for acicular crystals. I have also produced similar dendrites of iron by depositing the metal in the presence of a protector. Particulars regarding this will be given later in a paper on the effects of colloids on crystallization. The use of colloids to produce fine grain in the electrodeposition of metals is now familiar to you all.¹⁶

The consequences of fine subdivision are far reaching, affecting solubility (Hulett), fusibility (Doelter),

TABLE III. RELATION BETWEEN SIZE AND SURFACE AREA OR VOIDS

Grade of Shot	Dia., In.	No. per Oz.	Unit Area, Sq. In.	Area per Oz., Sq. In.	Vol. per Lib.	Water to Cover	Water Retained
Dust	0.04	4,565	0.005	22.8	76 c.c.	28 c.c.	20 c.c.
9	0.08	568	0.020	11.4	73	28	10
5	0.12	168	0.045	7.6	70	28	6
1	0.16	71	0.080	5.7	68	28	4
T	0.20	36	0.126	4.5	67	28	3
0 buck	0.32	9	0.322	2.9	67	35	2

chemical activity, electrical conductivity (Fink), vapor tension, solution pressure, specific gravity, adsorption, including adsorption of gases, and energy content (Graham). The most striking results are consequent upon the enormous development of free surface. Thus

¹²J. Alexander, *J. Soc. Chem. Ind.* (1909), "Colloid Chemistry and Some of Its Technical Applications."

¹³See papers of W. D. Bancroft, A. G. Betts; also J. Alexander, *J. Soc. Chem. Ind.* (1909)

¹⁴CHEM. & MET. ENG., vol. 24, p. 1065.

a cube of 1 cm. edge has a total surface of 6 sq.cm. (0.93 sq.in.); but if cut up into colloidal cubes of 0.01 μ edge there would be a million million million such cubes whose combined surface area would be 646 sq.ft. (93,000 sq.in.).

The following simple experiments show to the naked eye some of the effects of subdivision with consequent increase in free surface. Uniform weights of several standard sizes of lead shot (1 lb. each) were measured in a 100-c.c. cylinder, just covered with water, and what water would leave the shot was poured off. Table III and Figs. 6 and 7 show the results.

COLLOIDAL DISPERSIONS ARE HARD

Thus the amount of water held by the shot is substantially a linear function of the area, and will probably vary somewhat with the nature of the surface of the globules. While chemical attraction in the ordinary sense is out of question here, Bechhold has shown¹⁹ that adsorption varies greatly with the chemical nature of the adsorbent. With the finest shot ("dust") the surface forces, adhesion and adsorption, are already great enough to cause the wet shot to "clump" or stick together noticeably, and we get an inkling as to the power and extent of the enormous forces called into

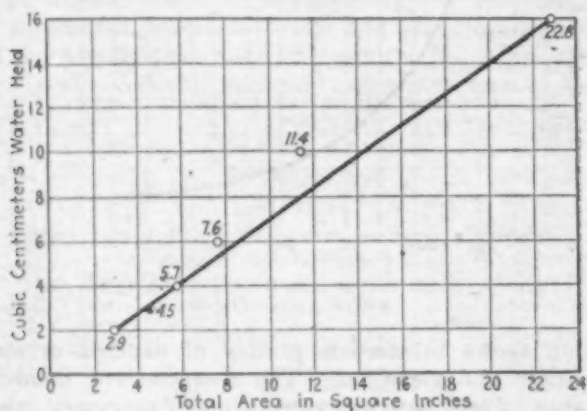


FIG. 7. RELATION BETWEEN AREA OF SHOT AND VOIDS

play by a great development in free surface. It is only natural, therefore, that colloidal dispersion should bring with it a great increase in hardness in metals.

Waiving the question as to whether the cementite in austenite is colloidal (and I think that at least as the steel freezes it becomes so), it seems that the very hard martensite is a colloidal dispersion of cementite in iron, a cementite ferrosol, with "hardenite" as its higher dispersion, troostite its incipient globulitic aggregation product, and sorbite and pearlite its successive coagulation stages. This view will perhaps reconcile the "allotropic" and "amorphous" theories which have been advanced to answer the question as to the constitution of martensite and the cause of its great hardness. According to the former,

The hardness of martensite is due to the presence in it of a notable proportion of "hard" β iron. . . . the acicular structure of martensite would be due to the formation, on the cleavage planes of the originally homogeneous γ iron solid solution, of needles of β iron. Normally such β iron would be obliged to expel the carbon which it had held in solution before the transformation, but, during quenching, time for such separation would not be available, and the β iron would be compelled to retain in "forced" solution, or in very fine suspension, the carbon thus unavoidably

retained *in situ*. The "amorphous" theory also explains the hardness of quenched steel by postulating the existence of an intrinsically hard but unstable transition product, which is formed when the transformation of the homogeneous γ iron solid solution into ferrite and carbide is hindered by quenching. Instead of identifying this hard substance with β iron, which has only a short range of stability in iron and low-carbon steels, the new (amorphous) theory ascribes hardening to the presence in the steel of amorphous layers similar to those which are believed to be the cause of the strain-hardening of ductile metals.²⁰

Considering martensite as a cementite ferrosol, a colloidal dispersion of iron carbide in iron, it is "amorphous" in the sense that its particles, even if actually crystalline, are mostly not microscopically resolvable; and, especially in low-carbon steels on quick chilling, there is a tendency to carry over into the solid state some of the α - γ allocolloid or " β iron," so that the iron-dispersing phase itself may represent a colloidal dispersion, consisting mainly of minute α iron particles.²¹ And because of the highly colloidal nature of the martensite and the consequent great development of free surface in it, it is extremely hard. Large percentages of oil colloiddally dispersed or emulsified in water yield very firm stiff masses, although both phases are liquid.

[Jeffries and Archer²² say:

There is no conceivable way in which a few per cent by volume of a strong constituent in disconnected particles could impart a new element of cohesion of the magnitude actually obtained. Their action must consist in rendering more effective the cohesion latent in the aluminum. The logical inference is that this is accomplished by the elimination of extended planes of weakness—that is, by slip interference. . . . Under the action of an external load tending to produce slip along these planes, the hard particles of CuAl must act as *keys*, mechanically obstructing any motion along the planes as a whole.

This mechanical comparison will undoubtedly appeal to engineers, but the action of surface forces, together with fineness of crystal grain (which in itself reduces the length of any one plane of slip), are quite sufficient to account for the phenomena observed. In making putty the addition of a few per cent of oil makes a viscous, "strong" mass with whiting; the finer the "filler" the stiffer the mass it makes with the same amount of oil—i.e., the more oil it "takes." Again, as S. V. Pickering²³ showed, 99 per cent of petroleum oil emulsified in 1 per cent of soap water makes an extremely stiff mass.

These illustrations indicate that a few per cent even of a weak constituent may produce relatively great hardness, provided that it is very finely dispersed. (See also discussion of the abbreviated form of the present series of papers by Prof. Le Chatelier and my reply thereto—*Proceedings*, Am. Inst. Mining and Metallurgical Engineers, vol. 64.)

This is quite contrary to what Jeffries and Archer state on page 1063: "We should not expect soft particles to produce hardening, because the 'keys' of soft substance would shear and thus assist rather than oppose slip. The term *soft* is used here in the relative sense only." Now, oil and water are certainly soft and scarcely act as "keys" that prevent slip in the cases above referred to. We must remember, however, that substances which are fluid in mass need not be so necessarily when finely subdivided. Thus the more

¹⁹Rosenhain, pp. 180-182.

²⁰Jeffries and Archer (*CHEM. & MET. ENG.*, vol. 24, p. 1065) have just shown with the X-ray spectrometer that quick chilling can save some of the iron in γ form.]

²¹*CHEM. & MET. ENG.*, vol. 24, p. 1061.

²²*J. Chem. Soc.*, vol. 91, p. 2002 (1902).

¹⁹"Colloids in Biology and Medicine," p. 29.

finely divided mercury is, the more it seems to act like a solid. With increasing subdivision, surface forces ordinarily negligible predominate.^{24]}

MAXIMUM HARDNESS OCCURS AT LESS THAN MAXIMUM DISPERSION

The fact that austenite, though harder than pearlite, is not as hard as martensite, indicates that the latter represents a point, or rather a zone, of maximum degree of colloidality²⁵—that is, there appears to be a certain degree of subdivision or dispersion, not necessarily the same with all substances, in which the dispersion system exhibits colloidal or surface phenomena to the highest extent, this effect declining not only with increasing aggregation or coagulation, but also with further peptization and the approach of true molecular dispersion, or the formation of smaller molecules.

[Jeffries and Archer in their paper on "Slip Interference"²⁶ designate the point of maximum hardness as the "critical dispersion." It had been referred to by Merica, Waltenberg and Scott.²⁷ In the preliminary paper on the zone of maximum colloidality referred to above,²⁸ it is stated:

The viscosity of reversible, emulsoid, or hydrophilic colloids, one of their marked characteristics, sometimes increases as the dispersed phase becomes finer (as in oil emulsions, homogenized milk) or sometimes as the dispersed phase becomes coarser (as with soaps, night-blue, butyric acid). In fact there seems to be with each dispersion a zone of maximum colloidality, above which viscosity decreases with coarser subdivision as the Brownian motion becomes sluggish (about 100 μ), and below which it also decreases as molecular dimensions are approached (about 5 μ), and the Zsigmondy-Brownian motion becomes violent. This zone has approximate limits and a crest or peak not necessarily the same with various substances—indeed we should expect specific variations²⁹.

The approach toward the zone of maximum colloidality from the side of coarse dispersion is illustrated by clays which hold increasing amounts of water as their particles become smaller. The approach from the side of molecular dispersion is illustrated by the experimental results of Martin H. Fischer³⁰ on the sodium salts of the fatty acids. The sodium salts of formic, acetic, propionic, butyric and valeric acids always give molecular dispersions with water. Sodium caproate (with 6 carbon atoms) begins to show signs of "holding" water, while the caprylate (with 8 carbon atoms) gives a jelly when one mol is mixed with 250 c.c. of water. With the higher acids in the series the water-holding capacity per mol of sodium soap increases rapidly as the molecules become larger: capric (C_{10}), 500 c.c.; lauric (C_{12}), 4 liters; myristic (C_{14}), 12 liters; palmitic (C_{16}), 20 liters; margaric (C_{18}), 24 liters; stearic (C_{18}), 27 liters; arachnic (C_{20}), 37 liters.

The appearance of a zone of maximum colloidality is not limited to the so-called emulsoid colloids. Thus with steel the Fe₃C-Fe dispersion reaches its maximum hardness in martensite, and becomes softer if the dispersion becomes greater (austenite) or less (troostite, sorbite, pearlite). A similar zone of maximum hardness exists in the dispersion of copper aluminide (CuAl)^{31]}.

The behavior of hypoeutectoid steels (containing less than 0.9 per cent C) is naturally complicated by the fact that the transformation of the excess γ iron (that in excess of the γ iron-cementite adsorption) into α iron, or the break-up of the α - γ adsorption (" β iron"), takes time and exhibits a lag which is most marked in the quickly cooled specimens. On the other hand, with

hypereutectoid steels (containing more than 0.9 per cent C) the excess of cementite tends to crystallize out in slowly cooled specimens and to yield some undecomposed γ iron-cementite "solid solution" in quickly cooled ones. To consider these in detail, and also the high-carbon "cast iron," would unduly extend the limits of this paper; but I must comment on the observations of McCance,³² who showed "that on adding carbon to iron, the hardness of the quenched steels increases up to 0.7 per cent C, and remains constant between this point and 1.18 per cent." This indicates a zone of maximum colloidal effect, which probably covers the zone of maximum degree of colloidality above referred to. The addition of manganese to steel, as Maurer has shown, retards the aggregation of the cementite so that ordinary slow cooling yields martensite, probably because the viscosity of the dispersion medium (iron) is increased by the manganese (melting point, 1,225 deg. C.), which by its surface or adsorptive action acts like a protector in opposing the aggregation of the martensite constituents; on the other hand, the manganese increases the speed of the transformation, when it finally does occur, because the manganese exerts its force then in the direction of the readjustment. Still larger percentages of manganese prevent any transformation at all, yielding austenite.

Lignite Carbonization—Carbonized Residue Briquets*

BY W. W. ODELL

Fuel Engineer, Bureau of Mines

OF RECENT years interest in the development of lignite fields and the production of beneficiated fuel has become more general or widespread, simultaneously with the increase in price of high-grade fuel. Not only is it recognized that our supply of high-grade anthracite is limited, but cognizance is taken of the fact that in many localities the average quality of the fuel now being purchased is not so good as that bought under the same name a number of years ago. This difference is primarily due to the increasing amount of incom-bustible material that is permitted to pass into a coal shipment as coal. The natural result of this higher ash content and resulting lower heating value, in conjunction with a higher price for such fuel, is that the clean lower grade fuels automatically become relatively more valuable.

The development and utilization of low-grade fuels is not new, but on this continent conditions have not heretofore been favorable to such enterprises. The abundance of the available supply of lignite in this country in locations where other fuel is obtainable only by a long freight haul from distant sources has made the lignite problem a serious one for domestic consumers in such localities as the Dakotas and Texas.

For many years it has been recognized by Dr. E. J. Babcock, dean of the mining engineering department of the University of North Dakota, that the solution of the lignite problem is of vital importance to the state of North Dakota, and to the development of certain industries in that state. The studies made under his guidance include briquetting the raw lignite, briquetting the dried and partly carbonized lignite, drying and

²⁴See "Surface Tension and Surface Energy," by E. Hatschek, Second Ed., 1919. On page 28 *et seq.* is a discussion of phenomena in metals.

²⁵This is the subject of a preliminary paper, since published, *J. Am. Chem. Soc.*, vol. 43, p. 434 (1921).

²⁶*CHEM. & MET. ENG.*, vol. 24, p. 1057.

²⁷"The Heat-Treatment of Duralumin," Bureau of Standards Bull. 150 (1919).

²⁸It is interesting to note that the sun repels particles of colloidal dimensions, although smaller ones as well as larger ones are attracted. See J. Alexander, "Colloid Chemistry," D. Van Nostrand Co., 1919, p. 37.

²⁹Fischer, *Chem. Eng.*, vol. 27, pp. 155-62 (1919).

³⁰"A Contribution to the Theory of Hardening," *J. Inst. and Steel Inst.*, 1914, No. 1, p. 192.

*Reports of Investigations, Bureau of Mines.

carbonizing lignite in rotary driers, horizontal retorts, beehive ovens, kilns and inclined ovens.

If briquets are made simply from dried lignite, other complications are met with in handling the material, such as the strong tendency for the dried lignite to ignite spontaneously. Also, the dried lignite does not lend itself well to briquetting. The conclusion reached in the studies by Dr. Babcock was that the best manner of producing a highly beneficiated fuel from lignite is to briquet a carbonized residue. The aim in general is to produce a fuel for domestic use which, on combustion, will liberate the greatest amount of heat per unit weight of fuel compatible with an economic method for its manufacture. It is appreciated that a fuel approaching anthracite may be desired for some purposes, whereas briquets capable of giving a longer flame on burning are desired for other uses. The problem as taken up at the University of North Dakota is naturally divided into two phases: First, the carbonization of lignite, so as to make a suitable material for briquetting, and second, the briquetting of the carbonized residue with the minimum amount of a suitable binder to form a firm, resistant and even-burning fuel.

EXPERIMENTAL PLAN

During the past summer (1921) experiments were conducted at the Hebron, N. D., substation under a co-operative agreement between the University of North Dakota and the U. S. Bureau of Mines, for the purposes of ascertaining what results might be expected commercially from a particular type of oven; what methods of control should be used; what yield of gas, tar and ammonia might be realized, and to learn more about the design of a carbonizer best suited for lignite. It is obvious that in erecting or designing a complete plant it is necessary to know the capacity of a unit carbonizer as well as that of the briquetting equipment, and in order to produce the finished product at the lowest possible cost, it is desirable to obtain the maximum capacity in the operation of the carbonizer. These and other important details were given particular consideration during the co-operative tests.

The plan of the work was to carbonize approximately 1,000 tons of raw lignite by continuous operation of the carbonizer, briquetting the residue into a firm, solid fuel, and to obtain meanwhile as many data as possible relating to the following:

1. Quality and quantity of gas obtained.
2. Quantity of gas required for carbonizing.
3. Behavior of lignite during processing.
4. Capacity of carbonizer.
5. Quality and quantity of residue obtained under various conditions.
6. Analyses of lignite, residue and the briquets made therefrom.
7. Binder requisites.
8. Character of briquets made.
9. Control methods.
10. Cost of briquetted residue.
11. Quantity of byproducts.
12. The design of apparatus suitable for carbonizing lignite.

This program was adhered to as nearly as possible throughout the experiments.

Various types and styles of retorts and carbonizers have been in use at different times during the previous investigations made by Dr. Babcock and associates at the University of North Dakota and the substation, the present construction being their most recent result of the continued study of the characteristic properties of lignite, and its behavior when heated.

The carbonizer used during the co-operative tests consisted of twelve inclined retorts (a double row of six), as shown in isometric perspective in Fig. 1. The upper ends are open, and a pile several feet high, of raw lignite, is maintained above them. The carbonized product is drawn off periodically from the lower ends, after being partly cooled by contact with the air ducts or recuperators at the bottom of the setting. Exhaust steam is used to complete the cooling, and is supplied so as to be in contact with the residue at the time it is discharged into the conveyor beneath.

The gas liberated is taken off into a hydraulic main (not shown in Fig. 1), where a uniform seal is maintained so as to keep a uniform and controllable pressure condition in the retorts. An exhaustor draws the gas from this main and forces it through a cooling system, where the tarry vapors are removed, and on to a mani-

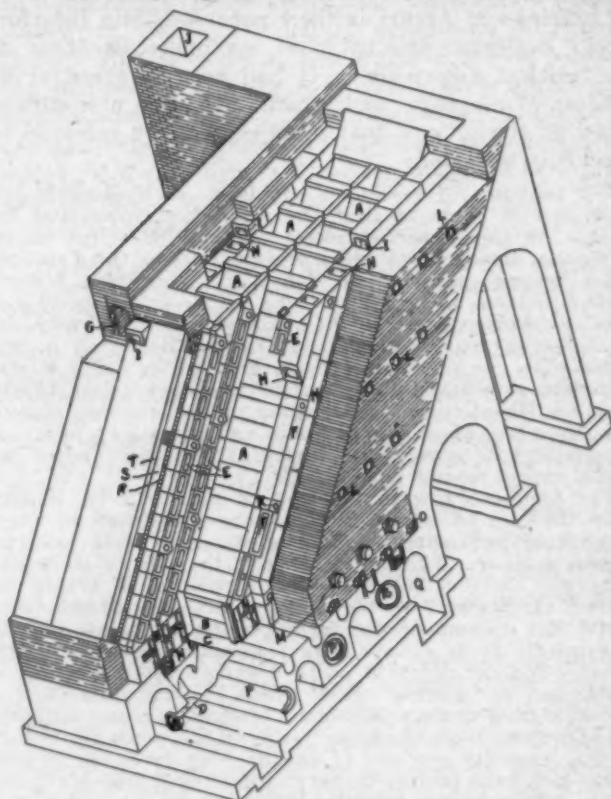


FIG. 1—LIGNITE CARBONIZER

A Inclined chambers. B Cooling chambers. C Discharging device. D Screw conveyor. E Heating flues. F Heating flues (end sections). G Waste heat flue. H Heating flues at sides of chambers. I Header for flues. J Stock. K Gas offtakes, openings to chambers not shown. L Gas offtake blocks to receive iron pipes. M Poke holes. N Preheating flues for secondary air. O Dampers for secondary air supply. P Manholes. Q Tunnel for cross-conveyor. R Firebrick (set rowlock). S Ashes. T Reinforced concrete.

fold supplying gas to heat the retorts. The gas is supplied to the lower flues, and preheated air is used for its combustion.

The capacity of such a carbonizer depends on the kind and quality of lignite used, as well as on operating conditions, size of retorts and other variables. Twenty tons per day of raw lignite was carbonized in this particular unit.

The briquetting equipment would briquet 2 tons of mix per hour. Belgian rolls were used, with 22-in. face, three rows wide, giving a pillow-shape briquet weighing approximately 2½ oz. The briquets obtained held up nicely in the fire, burned evenly, and withstood severe tests.

A complete report of the results obtained during the experiments is now in preparation by the co-operators.

Some New Petroleum Products*

The Vapor-Phase, Low-Temperature, Catalytic Oxidation of Fuel Oil and Other Crude Petroleum Fractions Is Shown to Yield a Series of Novel Chemical Products Which Appear to Have a Broad Range of Possible Industrial Applications

By J. H. JAMES

Professor of Chemical Engineering, Carnegie Institute of Technology

VERY little chemistry enters into ordinary petroleum refining, the process on the whole being based on physical principles. Where chemistry is introduced at all, as in acid agitation or sulphur removal by the Frasch and other processes, it is only for the purpose of removing certain substances, the presence of which impairs the value of the main product. The "cracking" processes developed in recent years are, however, an exception to the foregoing statement, for they involve chemical changes. The various commercial products of petroleum in present-day practice are those mixtures of hydrocarbons, the sum of which made up the greater part of the original crude.

The purpose of this paper is to describe in rather brief outline some work done in an attempt to prepare certain new chemical products by starting with petroleum as the raw material. The industrial application of the products thus obtained appears to belong in part to the oil industry and in part to industries decidedly remote. The fundamental idea of the process involved is the vapor-phase, low-temperature, catalytic oxidation of the aliphatic hydrocarbons of the petroleum.

While references are numerous in the literature to the many attempts made to oxidize petroleum hydrocarbons in the liquid phase, the first recorded work in the vapor phase appears to have been that of Walther.¹ Walther's apparatus, his arrangement and selection of catalysts and his temperature (he worked at a glowing red heat), as well as his air ratio (which must have been very high, as he maintained self-sustained combustion) all show, as our experiments have proved, that his proposed process was bound to be a failure. In the one experiment cited in his patent, he claims to obtain a liquid of lower boiling point than the original material treated, although his description of the other products is noticeably incomplete.

SELECTION OF CATALYST AND TEMPERATURE CONTROL

The author has found that the first requisite for success in obtaining yields sufficiently high and of satisfactory quality for industrial use is the selection of the catalyst. In this connection the oxides of certain metals of high atomic weight and low atomic volume, such as molybdenum and uranium, appear to be the most promising. Where compounds of closely related metals can be formed, such as diuranyl vanadate, very good results were obtained.

Numerous experiments have shown that many oxides have catalytic activity in this connection, but it is believed that for commercial development, all things considered, the best selection is within the group noted

above. Good results have been obtained by passing the mixture of hydrocarbon vapor and air through a thin layer of uranium oxide and then on through two layers of catalyst consisting of the oxides of molybdenum. The reason for the three catalytic layers, or, as we call them, "catalytic screens," will be noted later. The uranium oxide is used in the first screen because this oxide has the specific property of catalyzing to a marked degree the aldehydic stage of oxidation, so that where acids are desired as the main product, this preliminary step brings about a higher yield of acids, the aldehydic bodies going over to acids in the second and third screens.

In this process the temperature at which any reaction between molecular oxygen and aliphatic hydrocarbons begins is about 240 deg. C. Owing to the fact that the oxidation is slight at this temperature, and also to the further consideration that more heat is required to vaporize heavy hydrocarbons even with air, or air and steam present, higher temperatures than this must be employed. In general, the temperature should be as low as is consistent with good vaporization and a sufficiently rapid reaction; this varies of course with different petroleum fractions, but in any case no results of industrial value can be obtained above 500 deg. C. The writer's experience here would dictate that rather than work at temperatures approaching such a figure (where very high molecular weight hydrocarbons are being treated) it is better to run a small amount of the heavy petroleum fraction—such as wax distillate, for example—with a large amount of a fraction of lower boiling range, such as gas oil or heavy kerosene, thereby effecting ready vaporization of the heavy portion and allowing a lower catalyst temperature for the reaction.

Although steam may be used with good results, too much steam hinders the reaction, so that with very heavy fractions it will not do to depend entirely on steam as an aid in vaporization.

SOME PRODUCTS OF THE OXIDATION

The products formed vary somewhat with the catalyst and the temperature employed, but in general represent all the stages of the oxidation of aliphatic hydrocarbons from alcohols to oxygenated acids, together with hydrocarbons and oxidized bodies resulting from secondary reactions. These various bodies have not been studied in detail, but the acidic portion has usually been separated and the non-saponifiable portion, which we have chosen to call "congeneric oil," has been set to one side without any further treatment, except in a few instances, when it has been subjected to distillation. The acids are not true fatty acids, but are oxygenated acids, which are always aldehydic in character and respond to all the aldehyde reactions; and in fact their future industrial application may in some cases depend upon their

*A paper presented Dec. 9, 1921, at the Baltimore meeting of the American Institute of Chemical Engineers.

¹Brit. Pat. 21,941 (1905).

aldehydic character. For example, if the saponification of the oxidation product of any petroleum fraction be carried out with caustic soda, so much resinification of these acids takes place that when the acids are liberated from the soaps by a mineral acid they appear as hard resin-like substances. In fact, it is not at all improbable that these resinified acids will find use as cheap varnish gum and paint film substitutes.

If the saponification be carried out with calcium hydroxide instead of caustic soda, insoluble lime soaps are obtained of good color, since this base has very slight resinifying action on the aldehyde acids. The problem of making soda soaps of good color from these acids must be solved, the writer believes, by first making the lime soaps, then the free acids and finally carrying out the soda saponification under conditions which do not permit resinification to take place.

It is rather interesting to note that in the lime saponification it is very easy to make greases, the original components being lime soap, "congeneric oil" and water, and finally, if desired, only lime soap and congeneric oil. In fact there is always the problem of breaking up the grease, if it is desired to isolate the acids as noted above. It is believed that the best method for doing this is to remove the water by evaporation and then thin down the congeneric oil with one of the lighter petroleum fractions such as kerosene, filter off the lime soap and finally wash with a still lighter fraction, such as gasoline.

DEVELOPMENT OF NEW FUEL

Another phase of this work is the possibility of developing a new fuel from the cheaper fractions of petroleum by carrying out the oxidation at higher temperatures. These oxidized bodies thermally decompose to form both hydrocarbons of lower carbon content, and oxidized bodies of lower molecular weight. For example, with a fraction of Mexican fuel oil boiling from 300 to 360 deg. C. and running the oxidation process (by the three-screen method to be discussed later) so that the temperature is held between 380 and 400 deg. C. the liquid product obtained amounted to 80 per cent by volume of the oil treated. This product contained 30 per cent by volume of aldehydic fatty acids, 20 per cent by volume of other aldehydic bodies and the remaining 50 per cent consisted of other oxidized bodies and hydrocarbons. The latter were mostly of lower molecular weight than those of the original mixture, because of thermal decomposition of the oxygenated bodies. On distillation, 65 per cent of the product boiled under 300 deg. C. and of this fraction 18.4 per cent boiled below 200 deg. C. The oxygenated bodies are distributed through the entire range of fractions obtained by fractionally distilling the product, with more of the acids in the heavier fractions, and oxygenated bodies that have undergone thermal decomposition in the lighter fractions, along with hydrocarbons that have also been formed by thermal decomposition of the primary oxidation products. The distribution of the combined oxygen is shown by the following analyses made on a product obtained by the oxidation of a "pressure still tar," the residue from the "cracking" stills of one of the pressure cracking processes:

	Per Cent
Combined oxygen in fraction above 300 deg. C.....	4.1
Combined oxygen in fraction between 200 and 300 deg. C. 6.48	
Combined oxygen in fraction under 200 deg. C.....	12.32

This fraction under 300 deg. C. might be called "oxidized" kerosene, and its properties certainly justify



VAPORIZER (RIGHT), CATALYST CHAMBERS (LEFT)

work in the direction of having it utilized industrially as a fuel in internal combustion engines. It may be used in kerosene engines, or blended with gasoline for use in gasoline engines. Although it has a somewhat lower fuel value than ordinary kerosene, owing to its oxygenated character, it undergoes much better combustion in the internal combustion engine.

A sample of "oxidized" kerosene made from Mexican gas oil, having a specific gravity at 15.5 deg. C. equal to 0.863, gave a calorific value of 18,210 B.t.u. per lb. A sample of Mexican kerosene that had been given a rather mild oxidation had a specific gravity at 15.5 deg. C. of 0.855 and gave a calorific value of 18,696 B.t.u. per lb. Three samples of ordinary kerosene from various sources gave for their calorific value in B.t.u. per lb. 19,827, 19,867 and 19,944, from which it would appear that the calorific value of these oxidized kerosenes is not seriously low.

The use of this oxidation mixture—such as is obtained from gas oil, for example—as a starting material in "cracking" processes has been studied to some extent. As far as these experiments have been carried, it is evident that low boiling mixtures, within the gasoline range, can be obtained by the thermal decomposition of this mixture. These experiments are, however, only in the laboratory stage.

HEAVIER FRACTIONS POSSESS LUBRICATING PROPERTIES

The oxidation products obtained from the heavier fractions deserve attention from the standpoint of lubricant manufacture. Southcombe has recently brought forward the idea that a small percentage of free fatty acids added to a straight mineral oil lubricant would increase the lubricating character, particularly for those cases in which it has been necessary to use "blended" mineral and fatty oils. While this has been questioned, the writer ventures the opinion that at the present time the experimental evidence collected supports Southcombe.

The portion of the oxidation mixture that will be found suitable for use, either alone as a lubricant or as a blending agent, is the "congeneric oil" remaining after the acids have been removed. These high molecular weight oxidation products have valuable lubricating properties, a fact which appears to extend the Southcombe idea in another direction.

Although the idea is a daring one, the writer has suf-

ficient experimental evidence to make the claim that these oxidized oils will be found suitable for internal combustion engine lubrication. In this connection it should be remembered that the resinification property of these high molecular weight aldehydic bodies is brought out by treatment with the caustic alkalis. Under other conditions these bodies are really more stable than the fatty oils.

The sulphonation of the oxidation mixture has been carried out with a considerable degree of success. The acid portion sulphonates more readily than the other bodies present.

A promising application of the oxidation mixture in its entirety, just as it comes from the apparatus, is in the field of oil flotation. This mixture can serve primarily as a "frothing" oil in flotation mixtures, and numerous laboratory experiments have shown that it has, on the average, about one-half the frothing power of the best pine oil frother—that is, 2 gal. of this oxidized mixture will in general do the work of 1 gal. of the highest grade pine oil. When it is considered that this oxidized mixture can be made from fuel oil, available almost everywhere, and that pine oil f.o.b. New York costs \$1.50 per gal., it would appear that this product may find use in the concentration of ores by oil flotation.

From experimental evidence it is the acid content of the oxidized mixture that gives this material its frothing character. However, for flotation work there would be no gain in separating the acids, as the congeneric substances dissolve readily in all oil mixtures. The frothing oil in flotation formulas is but a small percentage of the total oil, hence the congeneric oils do no harm, and being made from fuel oil, which is commonly used as a collecting oil, the whole proposition works out as a very economical means of getting fatty acids into flotation mixtures.

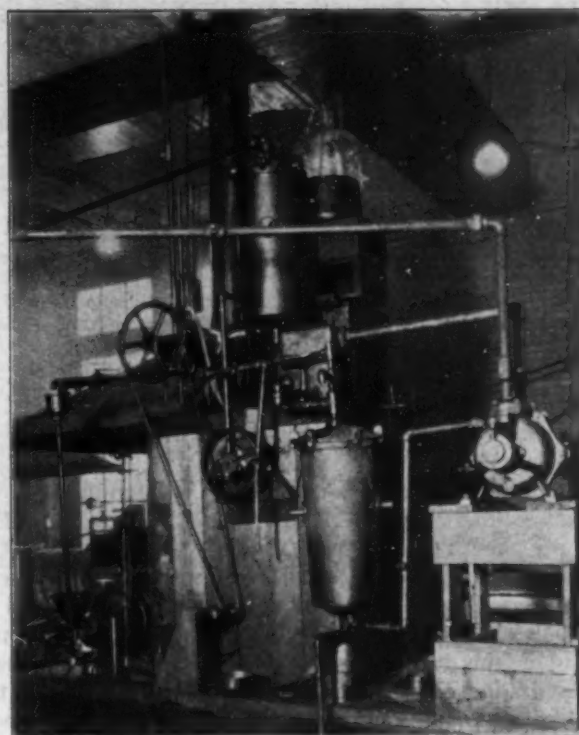
DEVELOPING THE APPARATUS

This process has been carried to what might be called the semi-industrial stage. In the laboratory of industrial chemistry at the Carnegie Institute of Technology there was set up a triple screen apparatus large enough to make about a barrel per day of the oxidized mixture from any petroleum fraction or blende that can be vaporized.

When the larger apparatus was first installed, one screen only of catalytic material was used, and the excess heat developed was carried off by a system of cooling pipes, the closed ends of which were imbedded in the catalyst.

Either air or water could be used as the cooling medium. In this oxidation of aliphatic hydrocarbons, the writer usually prefers to keep the temperature of the catalyst below 400 deg. C. (usually 280-380 deg. C.), hence in an apparatus larger than that used in the laboratory, the temperature tends to rise, because of the greater distance to any radiating surface and the non-conducting character of the catalyst and its carrier, which is usually asbestos.

The cooling tube apparatus worked fairly well, but later the double- and finally the triple-screen apparatus were developed. In the cooling tube system, one catalytic screen only was used, hence all the air that was to be introduced had to be given to the reaction at one time. With more than one catalytic screen, the air is introduced in portions before entering each screen, being distributed among the screens usually in equal amounts,



OIL FEED AND EXHAUST PUMP

but sometimes varying from this, if conditions demand it.

The triple-screen system also makes possible the use of different catalysts. It has been found that uranium oxide catalyzes the oxidation to the aldehyde stage, and at present uranium oxide is used for screen 1 and the molybdenum oxide mixture for screens 2 and 3.

The air is drawn into the system by a small pump, which in addition functions as a mechanical scrubber in aiding in the removal of the oil vapors from the gas stream. A parallel tube condenser placed about 15 ft. beyond the catalyzer (to allow for air cooling) is placed between the catalyzer and the pump.

SOME OPERATING DATA

The following example will serve to show the working of the apparatus:

Catalysts: three screens, all of molybdenum oxides, each 37.5 cm. in diameter and 1 cm. thick.

Oil used: Pennsylvania petroleum; a product sold at one time during the war as fuel oil by one of the Pittsburgh refineries: it showed the following on distillation:

First drop, 200 deg. C.	Per Cent by Vol.
200-250 deg. C.	11
250-300 deg. C.	51
300-350 deg. C.	34
Residue above 350 deg. C. and loss	4

Specific gravity of oil at 15.6 deg. C. was 0.819. Olefinic hydrocarbons (by the sulphuric acid test) was 7.5 per cent.

Time of run, 4 hours.

Average temperature of mixture leaving vaporizer, 310 deg. C.

Average temperature of first catalyst 335 deg. C.

Average temperature of second catalyst 370 deg. C.

Average temperature of third catalyst 370 deg. C.

Volume of air at room temperature and pressure passing

into vaporizer and on into first catalyst, 70 liters per minute.

Volume of air added at second catalyst, 30 liters per minute.

Volume of air added before entering third catalyst, 30 liters per minute.

For the second half of the run, "fume" gas (50 liters per minute) was taken from exit line and added as diluent to lower the temperature at screen number two.

Rate of oil feed to vaporizer, approximately 6 liters per hour.

Rate of water feed to vaporizer, approximately 6 liters per hour.

Vacuum on system at vaporizer, 5 cm. of mercury.

Gas Analysis:

	Per Cent by Vol.
CO ₂	2.9
O ₂	2.9
C ₂ H ₄	2.5
CO	4.8
Undetermined (mostly N ₂)	86.9

Volume of oil fed during run, 25.5 liters.

Volume of oily product (insoluble in water) recovered, 19.6 liters.

Specific gravity of product at 15.6 deg. C. was 0.86.

The product had approximately the following composition:

	Per Cent
Aldehydic fatty acids	31
Aldehydes (above 200 deg. C.)	20
Alcohols, volatile aldehydes and other oxidized bodies with hydrocarbons (by diff.)	49

The process works even better on oils having a lower market value than the Pennsylvania petroleum. For example, one of the easiest fractions to treat is what is commonly called "the gas oil fraction" from Mexican petroleum. The presence of sulphur compounds and of unsaturated hydrocarbons is no drawback to the application of the process, since the oils containing these bodies oxidize more readily. This therefore makes the process applicable to many refining wastes that now find their way into the fuel oil tank.

Patent applications covering the main process as well as its various ramifications have been filed in the United States and foreign countries.

Carnegie Institute of Technology,
Pittsburgh, Pa.

Atmospheric Nitrogen Production in Germany

The present extent of the production of nitrates in Germany by atmospheric fixation is discussed in *Commerce Reports* for Jan. 16, 1922.

Previous to the Oppau explosion in September, 1921, it was claimed that Germany was ready to supply, using the Haber-Bosch method alone, a combined production of 300,000 tons of nitrogen fertilizer, or enough with its other resources to take care of the most urgent needs of its agriculture. The aim of the industry, however, is to develop a production of 500,000 tons annually by this process alone, or sufficient to yield the maximum of vegetable produce from Germany's arable land, an amount estimated as adequate to feed a population of 100,000,000.

On account of the explosion, production ceased in the first plant in Germany to undertake the production of nitrogen by the Haber-Bosch process. The estimated output of this plant has been placed at 100,000 tons of nitrogen fertilizer per year.

Before the war Germany imported vast quantities of Chilean nitrates, together with various industrial by-products in the shape of nitrates of lime. In 1900 South America supplied Germany with 350,000 tons of nitrates; in 1909 with about 480,000 tons, containing 76,000 tons of pure nitrogen, valued at 95,000,000 gold marks. In 1913 German agriculture absorbed about 200,000 tons of nitrogen, sufficient to supply about 83 per cent of its population of 60,000,000 with cereals but insufficient to supply fodder for cattle.

Calcium-cyanamide factories in Germany have an output now of approximately 500,000 tons, with a nitrogen content of about 100,000 tons. Production of nitrogen fertilizers by the coke and gas industries before the war amounted to about 580,000 tons, with a nitrogen content of about 116,000 tons.

Corrosion Patterns on Cold-Worked Tin and Zinc

BY HENRY S. RAWDON, ALEXANDER I. KRYNITSKY AND
JULIUS F. T. BERLINER*

SPECIMENS of high-grade tin intended for pyrometric standards¹ were used in a brief study of the properties of tin after deep corrosion. The cross-section was reduced by cold-rolling from 2 by 4 cm. to a strip approximately 0.15 cm. thick, and the metal was then annealed for period of 2½ hours at 150 deg. C. Acidified solutions of stannous chloride were the corroding liquids used, alcoholic solutions rather than aqueous being employed on account of the influence of water in decomposing the salt. For reagents, a normal solution of stannous chloride to which hydrochloric acid was added to form solutions of the approximate concentrations 0.52N, 0.78N, 1.2N and 2.2N were used. The temperature was that of the room and varied between 12 and 30 deg. C.

The attack was distinctly more severe along the grain boundaries than in the interior of the grain. After a prolonged attack, it appeared that some of the grains had been detached bodily along the margin of the corroded specimen as is shown in Fig. 1. Corrosion was permitted to proceed for a period of 87 days and on sharply bending the corroded specimens, no evidence of intercrystalline fissures throughout the material was obtained except a suggestion of them in one case. In general, the metal appeared to retain its initial ductility.

Some of the specimens of tin exhibited a very peculiar and striking pattern upon corrosion which was independent of and superimposed upon the granular or crystal structural pattern. This is shown in Fig. 2, and it appears to be related to the rolling that the material received. That it is not entirely a surface roughening caused by adherence of corrosion products or by convection or diffusion currents within the corroding liquid appears evident from the fact that very slight corrosion (1 hour) was sufficient to reveal it and also that it was still very prominent after 4 days' attack. The regularity of this cellular pattern is striking.

No explanation as to its meaning can be offered from the evidence in hand, though it can be stated that the properties of the tin after corrosion do not appear to be affected to any appreciable extent by this feature of the structure. The fact that the metal was annealed would indicate that the etch pattern cannot be attributed to the uneven removal of a relatively hard "skin" on the surface of the metal.

ZINC

The material used for experiment was a high-grade sheet² zinc furnished for the purpose by the New Jersey Zinc Co. The sheet was stated to be in the annealed condition when received; the microstructure indicated, however, that all the effects of the mechanical working had not been removed, so an additional annealing was given to some of the material. The small specimens, after being cut to size for the corrosion

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*Physicist, Associate Physicist and Laboratory Assistant, respectively, Bureau of Standards.

¹The chemical analysis of the material indicated the following composition: lead, 0.007 per cent; copper, 0.003; iron, 0.002; a trace of each, arsenic and sulphur; antimony, not detected; tin (by difference), 99.998 per cent.

²The chemical analysis indicated the following composition: Lead, 0.04 per cent; iron, 0.02; cadmium, trace; sulphur, not detected; zinc (by difference), 99.94 per cent.



FIGS. 1 TO 3

Fig. 1—Pure tin after 87 days' corrosion in $N \text{ SnCl}_2 + 2.2N \text{ HCl}$. $\times 5$.
Fig. 2—Pure tin after 1 hour in $N \text{ SnCl}_2 + 0.6N \text{ HCl}$. $\times 5$.

Fig. 3—Annealed zinc after 17 days' corrosion in $N \text{ ZnSO}_4 + 2N \text{ H}_2\text{SO}_4$; cleaned before photographing with 5 per cent acetic acid. $\times 2$.

tests, were heated in an oil bath and maintained at a temperature of 350 deg. C. for a period of $3\frac{1}{2}$ hours and allowed to cool in the oil, the entire period above 300 deg. C. being approximately 5 hours.

Normal aqueous solutions of zinc sulphate to which various amounts of sulphuric acid had been added in order to give a series of solutions of increasing acid concentration were used as the corroding liquids. The results obtained after a period of 17 days at room temperature are summarized in Table I.

TABLE I.—LOSS OF WEIGHT OF ZINC DURING CORROSION

Spec. No.	Dimensions, Cm.	Area, Sq.Cm.	Corroding Solution	Loss of Wt. After 17 Days, * G.	Loss per Sq.Cm. per Day, Mg.
1	$4 \times 2.1 \times 0.12$	17.26	N zinc sulphate	0.018†	0.06†
2	$4 \times 2.1 \times 0.12$	17.26	N zinc sulphate + $N/4$ sulphuric acid	0.157	0.53
3	$4 \times 2.1 \times 0.12$	17.26	N zinc sulphate + $N/2$ sulphuric acid	0.698	2.38
4	$4.1 \times 2.1 \times 0.12$	18.7	N zinc sulphate + N sulphuric acid	1.291	4.06
5	$4 \times 2.2 \times 0.12$	19.1	N zinc sulphate + $2N$ sulphuric acid	2.600	8.00

*The scale was removed from the corroded specimens by immersion in 4 per cent acetic acid solution before weighing.

†Slight gain caused by incomplete removal of the corrosion scale.

The attack of the metal appears to be, at least in part, intercrystalline in nature, as is best shown by examination of the edges of the corroded sheets and the margins of corrosion pits. However, upon sharply bending the sheets after corrosion no pronounced evidence was obtained which would indicate that the metal had been embrittled or otherwise seriously affected in its properties as is the case with lead after corrosion under similar conditions.

The character of the corroded surface appears to have been determined in a very large measure by the mechanical working which the material previously received. The pits resulting from the corrosive attack were arranged in rather definite lines which coincided with the direction of rolling of the sheet. This feature was noticeable even in the annealed sheet, but more so in the commercially annealed metal. Fig. 3 shows an annealed specimen after corrosion for 17 days in $N \text{ ZnSO}_4$, plus $2N \text{ H}_2\text{SO}_4$. Results obtained by prolonged

corrosion in solutions of zinc chloride and of zinc nitrate with additions of the corresponding acid were very similar to those described above.

Upon sharply bending the specimens after the prolonged corrosive attack no satisfactory evidence was obtained which would warrant the conclusion that the metal had been seriously affected in an intercrystalline manner.

The Metallurgical Situation in France

According to figures reproduced in the French press, the total production of iron in France in 1921 was 2,074,732 tons, as compared with 3,265,000 tons in 1920 and 5,207,197 tons in 1913. The steel production for 1921 is given as 2,602,800 tons, as compared with 2,914,800 tons in 1920 and 4,686,866 tons in 1913. Thus the reduced activity in France is not as considerable as in Belgium, where the 1921 production of iron was only 34.7 per cent of the 1913 figure. The only country where production has increased is Germany, where, according to the same estimates, the production of iron rose from 7,000,000 tons in 1920 to 8,000,000 tons in 1921 and that of steel from 8,400,000 in 1920 to 9,400,000 tons in 1921.

A steady improvement is noticeable in the metallurgical industries in the Lyons district. The orders given by railway companies for locomotives and rolling stock and for repair materials have recently been so numerous that certain works are short of skilled hands. An improvement is remarked in the construction of machines for the cardboard and paper industries, and one establishment, which specializes in the construction of installations for slaughter houses and refrigerating warehouses, is seeking skilled hands.

Metallurgical works are profiting by the resumed activity of the chemical industries, which are ordering new vats and reservoirs, but the situation in the boiler trade is regarded as serious. Cast iron and steel foundries are receiving a certain number of orders, and although fewer workers are employed than in a normal period, work is active. Copper foundries are also more active, the tap industry having improved considerably.

Breakage Factors in Silica Brick Manufacture

A Critical Discussion of Those Factors in the Manufacture of Silica Brick Which Determine the Breakage Records—Properties of Silica Rock—Grinding—Effect of Bats—Workmanship—Drying—Setting in the Kiln—Burning—Methods of Firing

BY PHILIP H. JUNG

Consulting Chemical and Metallurgical Engineer

OF ALL refractories, silica brick are probably the most difficult to manufacture, or in other words, it is most difficult to obtain a low breakage record on silica brick. The reasons for this are, first, that the very nature of silica, considered from its physical aspects, makes it difficult to bond and shape as compared to an argillaceous substance, and second, that extreme care is required in burning and cooling, as silica will not stand rapid changes in temperature. Users of silica brick sometimes do not take this into consideration, and, in these cases, when brick are subjected to rapid heating and cooling, they soon fail and are condemned unjustly. At the present time manufacturers are interesting themselves in a silica brick machine and find that more intricate problems have to be faced than in the case of fireclay.

Breakage is a matter of uniformity, and the various factors that influence breakage are being more clearly recognized than heretofore. Investigations are continually being carried on to determine correct practice and then an effort is made to adhere to this.

PROPERTIES DESIRED IN THE SILICA ROCK

First of all, we have the character of the rock to consider. The physical appearance of silica rock or ganister varies considerably. Some of it is dark, some light, some streaked and the surface of some highly discolored. Of course, the purest rock is white. A colored rock is not necessarily one to be rejected. Very often a very high-grade rock is highly colored on the surface and gray throughout the mass. In the same quarry, the floe or surface rock will almost always vary from the solid measure rock. Some quarries will give an excellent floe rock and others a superior solid measure rock. Manufacturers differ in opinion as to which is the better. A clean-looking rock usually implies a pure rock, which forms a crude index of the chemical analysis. However, the physical features of the stone equal and perhaps exceed the chemical composition in importance. Sandstone which shows a very high percentage of silica is unsatisfactory for making brick, because it lacks physical strength. It invariably consists of rounded grains that are not tightly cemented to one another. On the other hand, there is a mountain of rock in the state of Washington which is pure quartz and translucent in appearance. It is entirely of a crystalline structure, and on fracture will break into small fragments with edges as sharp as a needle. Experiments have shown that a rock which is too pure, or in other words lacking some alumina and iron to aid in bonding, is difficult to bond even with a large percentage of lime, and this is especially true when the structure is all crystalline. Therefore the best rock for

making silica brick is one not too pure (under 99 per cent silica) and one which consists of crystals, which break into sharp fragments and which are cemented together with a ground mass of granular quartz. In this case the amorphous quartz, alumina and iron will aid in the bonding and help to make a physically stronger brick, other things being equal. Furthermore, such a rock will be difficult to pulverize. It is evident, then, that the selection of rock is of prime importance and that an experienced quarryman is absolutely essential.

After the rock has been crushed to the desired size, it is conveyed into bins, from which it is fed into pans having double mullers, milk of lime being added, and this mixture is ground and mixed thoroughly and constitutes what is known as silica mud. Sometimes bats are ground with it. What bats are and how they affect the situation will be discussed later on. The lime, if kept within certain limits, does not affect the breakage as much as was once thought. To be sure, it is an important factor and needs constant watching, but it cannot prevent a high breakage if other important factors are not uniform.

IMPORTANCE OF UNIFORM GRINDING

It has been mentioned above that the rock is ground to a desired fineness. How fine or how coarse this must be depends on circumstances. A coarse grind means more abrasive qualities, ability to stand greater wear and tear and greater porosity. A fine grind means better filling out of corners, denser brick and greater thermal conductivity. As a rule, brick for open-hearth furnaces are coarsely ground and brick for byproduct coke ovens and glass tanks are ground finer. It is quite difficult to get a uniform grind. Experiments have been made often, the utmost care being taken to have the same rock as near as possible, the pans being properly repaired and time identical, and yet divergent results have been obtained. My personal view is that the varying factor lies in the hardness of the rock. No doubt practical brick manufacturers will dispute this point and maintain that their rock does not vary enough in hardness to warrant this inconsistency in grind. However, although no series have been made conducted along this line to my knowledge—that is, to show the exact relation between variation in grind and hardness of rock—my belief is that a small variation in the hardness of the rock will cause a much greater variation in grind than is thought possible. At least personal observation and practical experience lead me to believe this. All told, grind is an important factor, and whereas it does not influence breakage as heavily as some other factors, it does have a tendency to affect workmanship, which will be discussed later.

The next thing to consider is the amount of water to add in the brick mud to make it plastic and workable. Moisture varies ordinarily from 7 to 13 per cent. Below and above these limits it is quite noticeable. Below 7 per cent the mud feels very dry to the touch and above 13 the excess can easily be squeezed out and is so apparent that brick with that amount of moisture that have just been molded and set aside to temper sag at the edges and the excess water appears in beads on the surface of the brick. When carefully watched, it is very easy for an experienced pan-runner to get between 10½ and 12 per cent day in and day out. It is remarkable how accurate the workmen become with practice, simply by feeling before dumping the mud on the table. When it is a trifle wet, say 12 per cent, it will help toward making a firmer bond than if it is a little drier. Strength tests have shown this. The moisture is not difficult to control and therefore does not cut much figure in the breakage item. Furthermore, molders refuse to work with mud that is too wet or too dry, especially if the brick are branded with the molder's individual brand, and therefore it is very seldom that brick enter the driers having this defect.

Along with the question of moisture and closely allied to it is that of introducing scrap. By this is meant the addition of dry mud obtained from rejected green brick in order to give the charge the right plasticity, or in other words, when too wet, to correct this fault. Inasmuch as so little is added to the ordinary charge, and then only at intervals, it has practically no bearing on the breakage.

EFFECT OF BATS ON BREAKAGE

A statement has been made previously concerning bats and their effect on breakage. The term bats applies to rejected burned brick which are used over again in preparing the brick mud mixture. I doubt whether there is any subject concerning the manufacture of silica brick about which there is so much controversy and which arouses so much ire. Up to the present time it has not yet been shown just what amount of bats is correct, if any. The consensus seems to be around 15 per cent. At the present time I know of three silica brick yards that differ on this question. For example, yard 1 issues instructions to its pan-runners to add so many 9-in. brick (6 lb. apiece) to each charge and attempts to adhere to this religiously. In this case the amount happens to be about 8 per cent. Yard 2 never adds any unless the breakage is unusually high, and then only to get rid of the excess and in small quantities in each charge. Yard 3, after some technical investigation in the matter, came to the conclusion that the effect on the strength of the brick was not very great, that is, up to a certain point. For a time bats were added indiscriminately in spite of the fact that the mixture was hard to work with and was detrimental to small breakage records, because rigid inspection has shown that a high percentage of bats does not give the brick the clear ring when tapped with a hammer. But later on this practice was discontinued.

Just how does the addition of bats affect the structure of the brick? It is quite evident that if two brick receive an equal degree of burn, one containing no bats and the other about 20 per cent, the first will have expanded further than the other, because the latter contained 20 per cent of material that had

already been burned and expanded. The natural inference would be if one part of the brick expands more than the other part, this might cause fissures and even a rupture of the brick. However, strength tests have not borne this out. In fact a small percentage of bats seems to make a little stronger brick, especially when added in a pulverized form. Moreover when being molded, it is unquestionably more difficult to bond a small piece of bat to a piece of raw rock than it is to bond a small piece with another. This, however, is self-corrective, inasmuch as in burning, when changing from free lime to tricalcium silicate, the chemical change is the same in either case, at least there would be the same knitting together, although, as noted above, it would seem physically as if fissures would appear. The question as a whole is as yet difficult of solution, but it is conceded at least that it affects breakage considerably, if only from a standpoint of rigid inspection.

WORKMANSHIP

We now consider the important item of workmanship. This and burning probably affect breakage more than any other two factors.

It is a curious fact that according to the popular mind, the only big requirement for a brick is to shape up well, or in other words to fill out the mold exactly, with edges sharp. This conception is due no doubt to the fact that the average person invariably thinks of a building brick, which of course must be straight, so that it can be laid right. When considering refractory brick, however, although workmanship is not everything, yet it is a great deal. In the first place, the molds are very carefully made, and the process of molding varies with the kind of brick being made. When ordinary 9-in. straight are being made, slop mud is used—that is, two handfuls are thrown in the mold simultaneously and with considerable force, the hands being about 6 in. above the mold. The impact is sufficient to fill the mold completely. It is then slicked off and the brick pressed out. In case of shapes, especially where the shape is large and intricate, the brick are more carefully made. The mud for this purpose is both finer and more dry, as noted before. The edges of the mold are filled in first and the mold partly filled with mud and then hammered. This is then stirred around to prevent cleavage and enough mud added to fill the entire mold, which is then slicked off as in the previous case. The molds are so made that they can be taken apart, thus freeing the brick easily. A brick that is not carefully filled out is usually spongy in appearance. Sometimes brick warp and are not exactly straight. This may be due to poor workmanship or else the use of mud that was too wet. However, brick sometimes warp in spite of every precaution. Workmanship is such an important factor in this department that rigid inspection is essential, and this, together with the fact that physical imperfections can be seen, ordinarily reduces to a minimum the breakage for which this department is directly responsible.

DRYING AN IMPORTANT FACTOR

After the brick are made, they are put on a rack-car and left standing in the open air to temper properly. This process permits the brick to dry very slowly and harden, an action not unlike the setting of cement. Special shapes are put on a hot floor and permitted

to remain there sometimes several days. After they are tempered, they are put in the driers. Temperature uniformity is of prime importance in drying and is difficult to obtain, owing to the fact that the old-time method of employing waste heat from the kilns is still utilized in brick plants, both because of economical operation and for want of something better to meet the situation. The hot air is drawn in by huge fans and the temperature is controlled by opening and shutting blades on the fan. Even then unless the temperature recorders are closely watched, there will be considerable temperature fluctuation. The incoming end of the drier must be comparatively cold compared to the outgoing end.

As the brick are placed in the drier, they gradually work their way forward, being pushed by others behind them and in this way they reach the hottest zone, which should be just before reaching the outgoing end. This sometimes is as high as 325 deg. F. The reason for this is that if they are suddenly plunged into a temperature of 300 deg. F. or over from ordinary temperature, the sudden formation of steam will cause cracks in the structure and the bond will be somewhat broken. In other words, shattering on a small scale is the result, and, although the same thing occurs on a much larger scale in rapid burning, the damage is just as severe, and it leaves the brick while yet in the green state in a friable condition and with a cracked sound when tapped with an inspector's hammer. Time and time again, brick that were apparently O.K. in other respects were in this condition and were set and burned. This not only represented a waste of time and money, but was misleading in investigating the cause of high breakages. I recall a startling example of a case where a sudden depression in the industry proved to be a blessing in disguise, because the management, having more time to investigate such matters because of diminishing orders, finally found a clue to what had caused them grave concern for months. After investigating every possible source of trouble, they found that fully 10 per cent of their breakage was due to rapid heating and lack of temperature control in the driers.

Owing to practical condition, at times some time elapses after the brick are taken out of the drier and are set. A series of experiments run to establish a relation between absorption of moisture by green brick and the weather conditions proved that in no case was sufficient moisture absorbed to give concern, and furthermore, even on long standing, the amount of moisture absorbed was negligible. Whereas this is but a minor matter in the manufacture of silica brick it proved that if any appreciable moisture was present, it came from improper drying and thus an alibi long used by the drying foremen was no longer available.

SETTING THE BRICK IN THE KILN

Although the setting has a great deal to do with breakage, it should not occupy a prominent place in a technical dissertation of this kind. Proper setting is a matter of skill backed by years of experience in the brick industry. In the first place, it should be noted that the kiln has been properly repaired, that the fireboxes are in good condition, the riddle holes well cleaned out and the kiln-floor as nearly level as possible. All this helps both in setting and burning. In down-draft kilns, such as are being used in the

silica brick industry, checkerworks of old brick are built in back of each firebox to divert the path of the flame upward toward the top and middle of the kiln, whence it is drawn down through the riddle holes and up the stack. Another reason for the erection of checkerwork is to prevent fire-flashing of ware nearest the firebox. The order or style of setting depends on the kind of shape being set. Ordinarily, difficult shapes are boxed in—that is, surrounded by benches of 9-in. or other small straight brick.

There usually is a preponderance of standard easy makes, such as 9-in., wedge, large 9-in., soaps, feather-edge, etc. These are usually nearest the fireboxes. The usual procedure of setting is to start with a course of tie-brick—that is, brick that have been burned over and over again and are used to support the courses of green brick that are being set. Several courses or rows of brick are set on top of this and then another row of the tie-brick. Sometimes brick are set on edge, either lengthwise or breadthwise, but in any case it is necessary to alternate this procedure with each row. This permits proper spacing between brick, which is important, as brick must have room to expand. After the setting is completed, a space is allowed for test brick and testing cones, the doors are sealed and coal in the fireboxes ignited with oil, pitch or other flammable material.

BURNING A MAJOR FACTOR IN BREAKAGE

We now come to the burning. This and the workmanship form the two major operations in silica brick making and ordinarily influence the breakage more than any other factor. Attention has been called to the fact that silica brick are difficult to make and that one of the principal reasons for this is found in the structure of silica. This becomes very evident when the subject of burning is considered. A silica brick must be heated slowly and cooled slowly. Rapid heating causes spalling or chipping off into slivers and even disintegration. Even when heating moderately fast the brick are apt to swell, causing excessive expansion, and sound brick do not result. Likewise rapid cooling causes fine cracks and slight disintegration. A fundamental fact is that a silica brick does not expand uniformly. Half of the expansion occurs below 600 deg. C. and the brick are burned to 1,500 deg. C. In speaking of expansion, it is well to remember that there are two kinds of expansion. The first or permanent expansion is that which occurs when a brick changes from the green state to a burned state, or technically speaking from quartz to cristobalite tridymite. In a well-burned brick this should be between $\frac{1}{4}$ and $\frac{3}{8}$ in. per linear foot. The other expansion is a temporary one which occurs when any substance is heated (except of course those substances that shrink on burning), and this expansion disappears on cooling. A well-burned brick does not mean one which has been burned to its extreme expansion limit, since it can be overburned as well as underburned. On the contrary, a very slight difference between the utmost expansion and actual expansion should remain, as this will help the brick fit tightly together when used in the open-hearth furnace or coke oven. This slight difference should be known and provided for. A well-burned brick will ordinarily have a clear ring, will measure up to standard if the amount of bats are not excessive, and will have a specific gravity under 2.36. The term specific gravity here refers to the true density of the

brick, irrespective of the porosity. The bulk density takes the brick as a mass and allows for the porosity. The figure varies according to physical structure of the rock used and its geographical location. Eastern rock burns to a lower density than Western rock.

In burning brick made for byproduct coke ovens, the shape and size of the brick are important considerations. The shapes are very often large and thick and sometimes intricate. It is therefore more difficult to burn these thoroughly than ordinary run of kiln. Such being the case, it quite frequently happens that a brick is burned so hard as to be called overburned. An overburned brick is just as apt to cause a high breakage as an underburned one. It is practically burned to its expansion limit in the first burn, or, in other words, a second heating and burning when used by the consumer in his ovens will bring about only a minute residual expansion, sometimes insufficient to knit the brick together. But the worst feature, from the manufacturer's standpoint, is that in overburning, minute fissures appear, which give the brick a cracked sound, causing a rejection. Furthermore, from an operating cost standpoint, it takes lots of coal to bring about an overburned condition. The consumer's specifications in this connection are now so rigid that the manufacturer in trying to give him a well-burned brick is apt to get a run of overburned brick. However, in most cases, he has met this admirably and the quality of coke-oven brick is constantly improving. An underburned brick, in the first place, has not the physical strength and from a consumer's standpoint is highly undesirable, as it will expand excessively when used causing tilting and failure of walls in the coke-oven.

HEAVY FIRING VS. LIGHT FIRING

Heavy or light firing is another point where manufacturers differ. In "heavy" firing, a lot of coal is put into the firebox at one time and at long intervals. During these intervals the coal is gradually burned to incandescence, causing a long flame which is necessary to burn silica brick. This argument is used by the advocates of this system. But the disadvantage is that when the next firing time is due, an addition of a lot of fresh coal causes a sudden decrease in temperature. The effects of this are self-evident. In light firing the coal is added in smaller quantities and at more frequent intervals, thus bringing about a greater uniformity of temperature. The disadvantage is of course that the fire is mostly in the coking stage and combustion takes place nearer the firebox because of a smaller flame and in this way it is more difficult to burn completely the brick that are farthest away from the firebox. The determining factor in the method adopted depends upon the character of the fuel available.

CONTROL OF THE BURNING OPERATION

In the question of burning control, several aids are used. The temperature is gaged by the pyrometric cones, but unfortunately they show only when the burn is completed—that is, fusing at the final temperature desired. It has been noted before that silica brick expand unevenly and the cones give no indication of what is happening during successive temperature changes. The use of pyrometers has been suggested to overcome this difficulty. They have not been successful in the silica brick industry and to

my mind have been unjustly condemned in some cases, due to the fact that they indicate the temperature at only one spot in the kiln and to the inaccuracy in recording the higher temperatures. This is no reflection on the merits of the pyrometer, as numerous papers have been written showing their successful application to many industries. This paper attempts only to record the actual experience of the pyrometer in the silica brick industry. The writer sees no reason why the pyrometer could not be used here in the future, even if only during the critical period, when most of the expansion takes place.

The other aid to proper burning is the draft gage. A uniform draft, like a uniform temperature, is desirable. Some works prefer the draft gage as a means of controlling temperature, but its use is open to discussion. Experienced users state that 0.4-in. is ideal but difficult to attain. Of course, the actual draft varies with the kind of fuel employed and also with the location of the gage.

Only experienced firemen should be employed, the test brick watched, and the appearance of the flame noted through the peep-holes. Old hands become very accurate in telling temperatures by this means. The cooling is the reverse of burning. Less and less coal is used until finally the fireboxes are sealed and then the air is gradually let in. The door is then taken down. Fans are sometimes placed at the fireboxes to assist in cooling. The time of firing usually takes from 5 to 8 days depending upon the kiln and cooling takes the same amount of time.

This practically covers the whole subject of breakage factors. Sometimes careless handling in taking brick from the kiln to the stockshed or cars increases breakage, the percentage from this source usually being very small. This, of course, requires the vigilance of the foreman of this department.

Huntingdon, Pa.

Mineral Production of Spain

A report recently published by the Ministry of Fomento ranks Spain as the second country in the world in the production of copper, the United States being first, according to an article appearing in the Jan. 23, 1922, issue of *Commerce Reports*. Ninety per cent of the Spanish production of this mineral is controlled by British interests, and most of it comes from the Rio Tinto mines, which are developed by foreign capital. In 1919 there were exploited 622 hectares of mineral copper, which produced 864,414 tons, valued at 13,387,261 pesetas at the mine.

Spain is second in the production of lead, according to the same study, and in 1919 produced 136,180 tons of lead ore, valued at 46,129,647 pesetas, and 41,875 tons of silver-bearing lead, valued at 10,259,351 pesetas. French capital controls the Penarroya lead industry.

In production of mercury Spain leads all countries, having produced in 1919 24,966 tons, valued at 6,356,435 pesetas at the mine mouth. This represents an exploitation of 196,554 hectares. All of the quicksilver is exported under contract with the Rothschilds. Production of nickel, chromium and similar minerals is insignificant.

Although most of the Spanish industries converting raw metals into finished products are very small, there are eight enterprises employing over 1,000 men and thirteen others employ over 500 men.

The Determination of Nitrogen in Steel

An Extended Review of the Literature Covering Past Attempts to Determine Nitrogen in Steel Is Followed by a Detailed Description of the Reagents and Apparatus Recommended for the Determination of Nitride Nitrogen

BY FREDRIK HURUM AND HENRY FAY

ALTHOUGH the presence of nitrogen in iron and steel has been an established fact for almost a century, it is surprising to find what a small amount of definite and reliable information is available on this subject. The reason why so little is known about nitrogen in steel is undoubtedly due to the difficulty of analyzing for this element.

The value and outcome of any investigation on the effect of nitrogen on steel depend on a reliable and practicable method of analyzing for nitrogen, and the writers endeavored to work out such a method and try out its merits.

The method as worked out and which proved to be very successful is described herein, together with a discussion of the bibliography bearing upon the subject.

HISTORICAL NOTES ON ANALYSIS OF NITROGEN IN STEEL

The first mention of any compound between iron and nitrogen was made by Berthollet¹ and Thenard, who permitted ammonia gas to act on iron wire at red heat and found that the weight of the iron scarcely increased but that the metal became brittle. The discovery of nitrogen in commercial iron and steel appears to be due to Schafhäütl,² who during his stay in England in 1839 pointed out that both white cast iron and the English cast steel contained nitrogen besides carbon, and he claimed to have determined this amount quantitatively. To determine the nitrogen in large steel samples, he used the Dumas method, burning the iron in vacuum with copper oxide and measuring the liberated volume of nitrogen. For small samples he heated the sample with caustic alkali and caustic baryta. Ammonia was formed, and this was absorbed by hydrochloric acid and determined as ammonium platinum chloride. Schafhäütl found results running between 0.2 and 1.2 per cent nitrogen.

In 1850 Marchand³ published the results of his experiments on heating steel with metallic potassium, endeavoring to obtain all the nitrogen in the steel together with some of the carbon as potassium cyanide. Marchand points out that it is very likely that ammonia and cyanogen are carrying nitrogen into the steel, both in the blast furnace and during case-hardening operations. In the blast furnace he attributes the result to ammonia in the fuel, and the formation of cyanides from alkali metals in the flux. When discussing the cementation process he says it is a well-known fact that animal charcoal is particularly effective in transferring iron into steel. He believes that iron and steel are likely to contain nitrogen as a nitrogen-carbon com-

pound, and mentions cyanogen and paracyanogen as likely.

Marchand recommends analyzing for nitrogen in steel by the same method which Lassaigne has proposed to use for every carbonaceous substance which contains nitrogen—viz., heating with potassium or sodium and determining the potassium cyanide. He heated the powdered iron samples strongly with metallic potassium in a glass test-tube and excluded the nitrogen of the atmosphere by conducting a current of hydrogen into the test-tube through a two-hole stopper. He never succeeded in finding nitrogen in steel whenever precautions were taken to exclude the atmospheric nitrogen. Marchand was, however, able to detect nitrogen when using Schafhäütl's method. In cast iron he found 0.03 per cent nitrogen, which was one-twentieth of the amount found by Schafhäütl. The results, however, he admits are very doubtful and concludes that the nitrogen does not exceed the amount of 0.02 per cent.

Buchner⁴ claimed that he was able to detect sulphocyanides in iron from Tyrol. This iron left when dissolved in hydrochloric acid a carbonaceous residue. He mixed 240 g. of this residue with potassium carbonate, this latter substance being entirely free from sulphates, cyanides and chlorides. The mixture was heated strongly in a small retort over a coal fire for 1½ hours.

The alkali in the fused mass was separated from the iron by extraction with water, and this colorless solution gave a blood red color with ferric chloride. This also happened with acid iron sulphate, but in neither case in alkaline solution. Buchner has excluded atmospheric nitrogen by submerging the neck of the retort in hydrochloric acid. He does not mention, however, the probability of exposing the retort to sulphurous and nitrous gases from the coal fire.

Buchner pointed out that a small amount of ammonia was absorbed by the hydrochloric acid, but the reaction with platinum chloride was not strong enough to warrant any quantitative determination.

In 1861 Fremy⁵ tried to determine the nitrogen by heating samples in a current of hydrogen and measuring the decrease in weight, assuming that all the nitrogen would be given off as ammonia. He claimed to have found considerable amounts of nitrogen in all his iron samples. Bouis⁶ refined the method of Fremy and found very much lower results, not over 0.18 per cent.

No positive results seem, however, to have been obtained until Boussignault⁷ in 1861 developed a method which today is used as the basis for nitrogen analysis. He dissolved the steel sample in dilute hydrochloric

¹Traite de Chemie, 1834, p. 424.

²The London and Edinburgh Philosophical Magazine, 1839-1840. J. prak. Chem., 1840, vol. 19, p. 409.

³J. prak. Chem., vol. 49, p. 451.

⁴Liebig's Annalen, vol. 73 (1850).

⁵Compt. rend., 1861, vol. 52, p. 332.

⁶Compt. rend., 1861, vol. 52, p. 1195.

⁷Compt. rend., vol. 53, p. 77.

acid and obtained the nitrogen as ammonium chloride. He then distilled this solution over lime, and titrated the ammonia in the distillate with sulphuric acid. Boussignault found only very small amounts of nitrogen in steel.

F. C. Calvert² made experiments on the solution of cast iron in acids. He found that dies of cast iron about 1 cm. square would dissolve slowly in acids without appreciably changing volume, but left a well-defined structure of carbonaceous matter high in iron and richer in nitrogen than the original. His experiments extended over long periods of time. He found that acetic acid would attack cast iron slowly but steadily for years without necessitating a renewal of acid. Other acids, however, dissolved the iron more rapidly, but would have to be renewed from time to time.

Boussignault's method was reviewed and criticised by Ullgren,³ who demonstrated that by dissolving 10 g. pig iron in concentrated hydrochloric acid, part of the evolved ammonia would pass over with the hydrocarbon gases, even when not applying heat, and this amount of ammonia could be determined by conducting the evolved gases through hydrochloric acid solution free from ammonia. By distilling this acid solution with excess of caustic lime, he could, when titrating the distillate with oxalic acid, find up to 0.2 mg. ammonia that otherwise would not have been accounted for when using, for instance, Boussignault's original method. He was further able to show that the amount of ammonia carried off with the evolved gases when dissolving steel samples in hydrochloric acid solution increased when a stronger concentration of hydrochloric acid was used. He then suggested using neutral cupric chloride solution for dissolving the steel sample and found in a sample of 2 g. gray pig iron 0.103 per cent nitrogen. Ullgren found that the steels would contain from 0.1 to 0.7 per cent nitrogen.

Rammelsberg,⁴ who used a similar method, found only 0.002 per cent nitrogen. In 1865 Rinman⁵ published in Stockholm the results of his work. He found only very small amounts of nitrogen in steel (0.005 to 0.016 per cent). After the proposal of Ullgren he also attempted to prevent the evolved hydrocarbon gases from carrying off any ammonia when dissolving the sample. He distilled the solution as usual and titrated the ammonia in the distillate with oxalic acid.

NO REACTION BETWEEN IRON AND NITROGEN

Stahlschmidt⁶ in his paper "Beiträge zur Kenntnis des Stickstoffeisens" reported the formation of iron nitride containing 10.8 to 11.4 per cent nitrogen, when using Fremy's method of heating ferrous chloride with ammonia below red heat. This compound would correspond to the formula Fe_3N . He attributed the difference in the value of 0.6 per cent nitrogen to incomplete reaction or formation of ammonium iron chlorides not easily vaporized. Stahlschmidt was not able to find any reaction at all between free nitrogen and pure iron, even when using freshly reduced spongy iron. He was able to show that free nitrogen would not combine with iron even in the nascent state. In this latter experiment he heated iron oxide in a mixture of nitrogen and hydro-

gen. The water formed from this reaction was free from ammonia and the iron free from nitrogen.

Stahlschmidt further reported that iron nitride, when brought to a red heat in contact with steam, decomposed with formation of iron oxide and ammonia. He also showed that hydrochloric, sulphuric and nitric acids would dissolve nitride rapidly with formation of ammonia salts. He reported that iron nitride was not attacked at normal temperature by the halogens, but was attacked at an elevated temperature. The specific gravity of iron nitride he found to be 6.03.

At about the same time Stuart and Baker⁷ attempted the analysis of nitrogen in steel, but in most cases could not detect any. They used Fremy's method and took every precaution of purifying and drying the hydrogen gas.

ALLEN'S RESEARCHES

Allen⁸ in 1880 tried to determine the nitrogen in steel by means of steam which he passed over the red-hot sample, making use of Stahlschmidt's previous observation. The iron nitride was decomposed, giving ammonia and iron oxide, and the ammonia was collected in the condensed vapor and determined. Allen did not get any reliable results with this method. Afterward he had better success with Boussignault's method, using Nessler's reagent to determine the ammonia in the distillate. He distilled the solution over lime. Allen's colorimetric method was adopted and used later to a great extent for the determination of nitrogen in steel.

Harbord and Twynam⁹ used Allen's method without any modifications in their researches, and found that steels examined by them would contain from 0.000 to 0.024 per cent nitrogen. Langley¹⁰ in his results used Allen's colorimetric method, with the modification that he substituted sodium hydroxide for calcium hydroxide, and he also attempted to purify this alkaline solution by destroying any nitrites and nitrates by means of a copper-zinc couple.

Tholander¹¹ dissolved the steel sample in dilute sulphuric acid and distilled over sodium hydroxide solution. He used the iodide-iodate method to determine the ammonia in the distillate. This method seemed to work out very nicely. Braune¹² published in 1906 the results of his extensive work on nitrogen in steel, a work which covered several years and aimed to render a complete account of the subject. Braune used the colorimetric method based on Nessler's reagent, and analyzed a great variety of steel samples.

Braune suggested using 1 g. sample for 0.03 to 0.005 per cent nitrogen in the steel sample and smaller samples for higher contents. For dissolving 1 g. of steel he used 20 c.c. hydrochloric acid of sp.gr. 1.124. He filtered this ferrous solution and distilled it over 20 c.c. potassium hydroxide (equivalent to 20 c.c. hydrochloric acid sp.gr. 1.124). Braune then determined the amount of ammonia in the distillate with Nessler's reagent. He recommends taking 2 c.c. standard Nessler's reagent and diluting to 10 c.c. He then adds the whole at once to the distillate and stirs. The

²Compt. rend., vol. 52, p. 1315.

³Liebig's Annalen, 1862, vol. 124, p. 70.

⁴Monatsberichte d. kgl. preuss. Akad. d. Wissenschaften zu Berlin, 1862.

⁵Vetenskaps-akademiets forhandlingar, Stockholm, 1865, p. 143.

⁶Pogg. Ann. (1865), vol. 125, p. 32.

⁷Chem. News, vol. 10, p. 245.

⁸Iron and Steel Inst., 1880, No. 1, p. 181.

⁹Iron and Steel Inst., 1896, p. 2.

¹⁰Private report from Prof. J. W. Langley, Pittsburgh, to A. Blair, cit. Blair: "Chem. Analysis of Iron and Steel," seventh edition.

¹¹Jernkontorets Annaler, 1888.

¹²Jernkontorets Annaler, 1906, p. 671.

solution is then diluted to 150 c.c. In a special sample tube the color of this solution is matched to the color of a standard solution. This standard solution is prepared by dissolving 0.038147 g. ammonium chloride in 1 liter (i.e., 1 c.c. to 0.01 mg. N_3). He now takes 3 c.c. of this standard solution, treats it with Nessler's reagent and dilutes it to the same color intensity as the distillate. From the volumes used the nitrogen content is then computed.

Braune made tests and confirmed Stahlschmidt's assertion that all the nitrogen in a soft steel (0.06 per cent C) would be present as ammonium salt after dissolving the sample in hydrochloric or sulphuric acid. Braune also extended his researches to determine whether or not nitrogen might be present in the insoluble matter (graphite and temper carbon) left when dissolving a steel sample in acid.

He was not able to find any nitrogen in this residue and came to the conclusion that contradictory results by previous experimenters were likely to be due either to inexactness of method or to the ease with which this residue would absorb nitrogen from the atmosphere. Braune, however, admits the possibility of secondary reactions resulting in precipitation of a black matter from the acid with the carbon in the steel, evidently an organic compound of ammonia. Braune points out that in the color carbon test it is not the nitrogen from the steel but the nitrogen from the nitric acid that takes part in the reaction and results in the organic compound rendering the brownish color.

METHOD OF GRABE AND PETREN

Grabe and Petren¹⁹ made a thorough investigation on the methods of analysis of nitrogen in iron and steel. They used the method involving the use of potassium iodide and potassium iodate in the presence of dilute acid and made comparisons of this method with the colorimetric method as used by Braune. Grabe and Petren followed the ordinary procedure of dissolving the steel sample in acid and distilling this solution with an excess of alkaline solution. They collected the distillate containing the ammonia in 5 c.c. N/20 sulphuric acid so as to insure complete absorption of the ammonia as ammonium sulphate. They then titrated the iodine set free by the excess acid with sodium thiosulphate after having added potassium iodide and potassium iodate. They came to the conclusion that the colorimetric method was by no means exact enough and found that results obtained by Braune would disagree widely with results obtained with the iodide-iodate method. They showed that traces of nitrites in the alkalis used for distilling would to a great extent effect the results, and in some cases the nitrogen from this source would exceed the amount of nitrogen in the steel sample. However, they believed that hydrocarbon compounds (18 to 20 per cent of which may remain in the ferrous solution) would interfere with the iodine titration. They held the belief that unsaturated hydrocarbon compounds of the olefin series might combine with the iodine.

Tschischewski²⁰ asserts that the iodate method will give higher results than the colorimetric method of Nessler. He attributes this to the formation of amines, which are formed when dissolving the steel and which have a much lower coloring effect than ammonium

chloride toward Nessler's reagent. Tschischewski suggested using a 6-g. steel sample and dissolving in 35 c.c. hydrochloric acid of sp.gr. 1.19 and adding 50 c.c. pure water. He distilled his ferrous solution with 40 c.c. potassium hydroxide (1:1) to 50 c.c. water. The distillate was collected in 20 c.c. N/100 sulphuric acid.

W. Herwig²¹ determined nitrogen in iron and steel and used for his analysis a 5-g. sample which he dissolved in 50 c.c. hydrochloric acid of sp.gr. 1.124 and to which he added 40 c.c. water. On distilling this solution he prescribed addition of potassium hydroxide until the solution became only slightly alkaline. The distillate was collected in 20 c.c. N/100 sulphuric acid.

IODIDE-IODATE METHOD RECOMMENDED

The various methods suggested in the literature were subjected to critical examination and comparative tests, with the result that the iodide-iodate method seemed most worthy of further study. This method was subjected to detailed study and with certain minor modifications and attention to details it is herewith recommended as being the most satisfactory method for the accurate analysis for nitrogen in steels. The

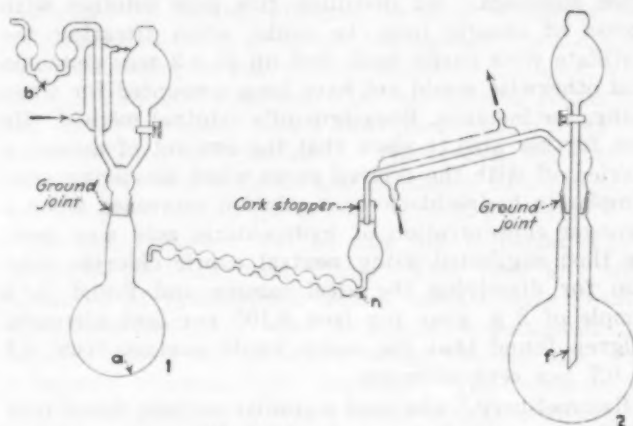


FIG. 1—DISSOLVING FLASK. FIG. 2—DISTILLING FLASK

method has not been tried on high-chromium or high-tungsten steels, but it gives satisfactory results on high-speed steels and all ordinary steels.

METHOD OF ANALYSIS APPARATUS

Dissolving flask should be such as shown in Fig. 1, having a dropping funnel, condenser and bubble tube connected with the flask by a ground glass joint. A convenient size is 200 to 250 c.c.

Distilling flask should be an apparatus such as shown in Fig. 2, consisting of flask, dropping funnel and condenser connected by a ground glass joint. The receiver is a convenient form to use, although a simpler form may be substituted.

REAGENTS

Pure, ammonia-free water is prepared by distilling distilled water with a solution of alkaline potassium permanganate made by dissolving 200 g. potassium hydroxide and 8 g. potassium permanganate in 1,100 c.c. distilled water, and then concentrating by boiling to 1,000 c.c. This solution is added to the water to be purified in the ratio of 1:10. Distillation is then carried on until a test of the distillate made with Nessler's reagent shows freedom from ammonia. Further dis-

¹⁹Jernkontorets Annaler, 1907.

²⁰Stahl u. Eisen, 1908, p. 394.

²¹Stahl u. Eisen, 1913, p. 1721.

tillation produces water, which may be collected for use in the analysis. It is advisable to use a condenser tube of tin.

Four hundred grams sodium hydroxide is dissolved in 1 liter of water for this reagent. It is likely to contain nitrites, which might be reduced to ammonia by the ferrous hydroxide when distillation is made during the analysis. Zinc finely covered with deposited copper is used for destroying the nitrites and to some extent the nitrates. The zinc is kept submerged 10 minutes in dilute copper sulphate and washed with distilled water and a small amount of it is permitted to stand for 24 hours at 50 deg. C. in contact with the sodium hydroxide solution." Nitrites are then reduced and the sodium hydroxide solution decanted off. The solution is then boiled in a distilling flask until the ammonia has been expelled. The solution is then brought to the same molal concentration as the hydrochloric acid solution of sp.gr. 1.12. Small amounts of nitrates present do not interfere with the analysis, as they are not easily decomposed by ferrous iron so long as the concentration is low (Braune).

Pure hydrochloric acid will always contain some traces of ammonia and should be purified before being used for dissolving the metal. Hydrochloric acid of 1.124 sp.gr. can be recommended for dissolving the steel sample. Prepare pure hydrochloric acid solution of sp.gr. 1.12 by distilling concentrated hydrochloric solution with addition of a little concentrated sulphuric acid and absorbing the hydrochloric acid gas in pure water, prepared by distilling over potassium permanganate solution.

Potassium iodide and potassium iodate may be obtained free from impurities which affect the analysis. A single recrystallization suffices to remove traces of free alkali. A solution of each salt is prepared by dissolving 5 g. of the respective salt in 100 c.c. of water.

Sodium thiosulphate solution, N/100, is made by dissolving 2.5 g. of crystallized sodium thiosulphate in pure water; dilute to 1 liter.

Sulphuric acid, N/100: Dilute 0.3 c.c. concentrated sulphuric acid with water to 1 liter. Standardize against pure sodium carbonate or by means of barium chloride.

SOLUTION OF THE STEEL

Approximately 5 g. of steel is placed on the bottom of the dissolving flask *a* (Fig. 1). About 7 to 9 c.c. hydrochloric acid (1.12 sp.gr.) is placed in the bulb neck *b*, so as to seal this gas passage. Through the dropping funnel is introduced 40 c.c. hydrochloric acid (1.12 sp.gr.) and the flask *a* is slightly heated. The steel sample will rapidly dissolve, the evolved gases passing through the water-cooled condenser and out through *b*.

Vapors are condensed in the water-cooled tube and returned to flask *a*. Neck *b* washes the evolved gases so that any ammonia which otherwise might be carried off with the escaping hydrogen and hydrocarbon gases will be retained in the hydrochloric acid. The water-cooled condenser should not be omitted, as it is an essential feature of the apparatus.

When the steel has been completely dissolved all the nitride nitrogen remains as ammonium chloride in the flask *a* with the exception of traces of ammonium chloride to be found in the bulbs *b*. The contents of

the latter are washed into *a* and the contents of *a* are then washed into the dropping funnel of the distilling flask, Fig. 2.

DISTILLATION OF THE SOLUTION CONTAINING AMMONIUM CHLORIDE

In the distilling flask as shown in the sketch is placed at least 50 c.c. of the sodium hydroxide solution, 300 c.c. of water, 10 c.c. of a potassium permanganate solution (8 g. KMnO_4 and 200 g. NaOH dissolved in 1,000 c.c. water). On the bottom of the flask is placed small coils of nichrome wire to insure quiet boiling. The liquid is then boiled until part of it is distilled over.

The receiver *n*, containing 10 c.c. N/100 H_2SO_4 , or a larger exactly measured amount, is then attached to the condenser and care is taken that the position of the receptacle is kept in such a way that the bend *n* is sealed with the acid. The acid ferrous solution, which up to that moment has been kept in the drop funnel, is then gradually run down into the distilling flask.

The boiling immediately accelerates, as the liquid in the distilling flask will give off ammonia and hydrocarbon gases, and the ammonia together with water vapor begins to collect in the water-cooled condenser and drops will soon run down into the receiver. After a few minutes of boiling all the ammonia has passed over into the receptacle *n* and has combined with the sulphuric acid.

Violent boiling and detrimental shocks are apt to occur when distillation has proceeded for a certain time. For this reason it is advisable to retain a small part of the ferrous solution in the dropping funnel instead of adding all the ferrous solution to the distilling flask at the beginning. When the few remaining drops of acid ferrous solution are finally added to the distilling flask at the end of distillation, additional volumes of hydrocarbon gases revive the boiling of the alkaline liquid and prevent accidents.

When properly handled the process of distillation lasts only a few minutes and sufficient alkaline solution can be kept in the distilling flask to make it possible to run a series of four or five analyses without interrupting the boiling.

COLLECTING THE DISTILLATE IN SULPHURIC ACID

Before beginning the distillation it is necessary to attach the receiver *n* to the end of the condenser tube as shown in Fig. 2. The connection is made airtight by a cork stopper.

In the bend *n* is the sulphuric acid, which has been carefully measured out from a burette. The sulphuric acid completely seals this bend. Under these circumstances no ammonia can escape, but all of it will be retained as ammonium sulphate in the receiver whether it escapes from the distilling flask as gas or is collected in water drops in the inclined condensing tube. Distillation is continued until about 50 c.c. has been collected in the receiver. The progress of distillation can be readily controlled as one bulb after the other is filled with the distillate and the gases pass through as bubbles. The distillate will always smell strongly of hydrocarbons.

When distillation is finished, the receiver is detached and the distillate, containing all the ammonia as ammonium sulphate, is poured into a small beaker and is titrated. The distillate should always contain an excess

¹Cit. Braune (Swedish Dept. Testing Materials.)

of free sulphuric acid and this amount of free sulphuric acid must be determined.

The liquid in the receiver, originally consisting of 10 c.c. N/100 sulphuric acid or any other exactly determined volume, is now partly a mixture of ammonium sulphate and free sulphuric acid. After this solution has been transferred to a beaker, 4 c.c. potassium iodide solution and 2 c.c. of potassium iodate solution are added and the liberated iodine is immediately titrated with N/100 sodium thiosulphate.

Immediately after this titration it is necessary to make a second one. For this purpose 10 c.c. N/100 sulphuric acid or exactly the same amount as originally used in the receiver is measured from a burette and the same volume of iodide and iodate solution is added. The iodine set free is again titrated with sodium thiosulphate and the amount of sodium thiosulphate recorded. The difference in the two values represents the amount of sulphuric acid equivalent to the ammonia absorbed.

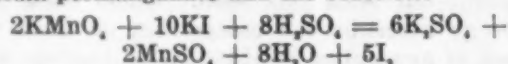
NOTES ON THE PROCEDURE

Nitrogen exists in steel as iron nitride, Fe_3N , which is readily decomposed by hydrochloric acid with formation of ammonium chloride. Ammonia is set free from ammonium chloride when heated with sodium hydroxide, and may be collected in sulphuric acid, which must be present in excess. Free sulphuric acid, in small amounts, may be determined with great accuracy by making use of the following reaction:



The amount of iodine liberated is a direct measure of the sulphuric acid, and consequently of the nitrogen, and may be determined by means of N/100 sodium thiosulphate. When the N/100 H_2SO_4 is measured for the receiver a similar amount should be measured and treated with iodide and iodate so as to get the value of the N/100 $\text{Na}_2\text{S}_2\text{O}_5$. The difference between the amount of iodine liberated in this blank determination and the amount set free in the actual analysis represents the amount of H_2SO_4 not neutralized by the ammonia, and hence gives a value for the amount neutralized. Inasmuch as 3I_2 is equivalent to $3\text{H}_2\text{SO}_4$, from the above equation it follows that 3I_2 is equivalent to 6N, or I_2 is equivalent to N_2 . Knowing these values, the nitrogen content of the steel may be calculated.

Sulphuric acid is used as the standard basis for all calculations, as its value remains permanent. Sodium thiosulphate, on the other hand, changes from hour to hour and should always be checked for each series of analyses. It should be checked against the sulphuric acid using the iodide-iodate reactions, and occasionally against iodine, making use of a carefully standardized potassium permanganate and the reaction:



Glass-stoppered apparatus is essential if accuracy is desired. Care should be taken to prevent caustic soda coming in contact with the ground joints, and the joints should always be wet with pure water before closing.

The dropping funnel extends below the liquid in the distilling flask, otherwise there is danger of ferrous chloride spattering on to the hot walls of the flask and liberating hydrochloric acid.

It would be advantageous to have the condenser tube made of tin or quartz, otherwise a blank of about 0.0003 g. nitrogen should be made for each 50 c.c. of distillate.

The presence of hydrocarbons has apparently no effect

upon the iodine titration. This was established by adding ammonium chloride in known amount to a hydrochloric acid solution of an annealed high-carbon steel and putting it through the regular operations. In every case the total nitrogen was recovered, even though the distillate smelled strongly of hydrocarbons. In this respect this method has decided advantage over the Nessler method.

The following different steel samples were analyzed and the results are given as characteristic with regard to nitrogen in ordinary steel samples. The analysis shows that the amount of this element present is very small in the cases examined, particularly in the three high-speed steels. Several analyses are given below:

Steel	N as Nitride Per Cent
Swedish crucible steel.....	0.0006
High-speed steel No. 1.....	0.0011
American ingot iron.....	0.003
High-speed steel No. 2.....	0.0005
High-speed steel No. 3.....	0.0005
Tool steel No. 1.....	0.011
Crucible steel.....	0.011

From this table it seems that with the exception of the tool steel No. 1 the amount of nitrogen is apparently negligible. In this exceptional case, however, it may rank in influence probably with other impurities such as sulphur and phosphorus, and should not be omitted from a complete analysis statement.

In steels which have been case-hardened by almost any of the commercial methods, the nitrogen content may rise to as much as 0.50 to 0.75 per cent.*

The Tanning Industry in Russia

Commerce Reports for Jan. 23, 1922, reproduces a statement appearing in the bolshevik press to the effect that 1,775 tanneries, large and small, were in operation at the end of June, 1921, in the whole of Soviet Russia. During the first 6 months of 1921, the statement indicates, 3,451,000 hides were tanned, as compared with a total of 2,700,000 for the same period in 1920, an increase of about 28 per cent. The actual production during the first half of 1921 represents 88 per cent of the prearranged program of production of the tanneries, according to the bolshevist statement.

Since the decree was issued some time ago permitting private persons to engage once more in the operation of industrial establishments a considerable number of the tanneries, all of which had been "nationalized," have been leased for private operation.

The government has retained a number of the larger tanneries, however, and will continue to operate them as government properties.

Vapor Luster on Pottery

An investigation of lusters for pottery decoration has recently been made by the Bureau of Mines to determine the most suitable glaze compositions for taking vapor lusters. Luster decorations are applied to pottery by two methods: First, by applying in paste condition suitable metallic salts to the surface of the ware and firing at a dull heat; second, by vaporizing such salts in the flame of iridescent effects similar to that of favrile glass. Results indicated that glazes containing B_2O_3 and PbO produced the best luster effects, the intensity of the luster increasing with larger amounts of these two components in the glaze.

**Fay, CHEM. & MET. ENG., vol. 24, No. 7, p. 289.*

Industrial Uses of Phosphoric Acid and Phosphates

Phosphoric Acid Is Employed in Clarifying Sugar, Preparing Soft Drinks and Pharmaceuticals—Use of Calcium Acid Phosphate in the Production of Baking Powder and Self-Rising Flour—Formulas for Preparing Food Phosphates—Consumption of Sodium Phosphates

BY JACOB T. MECKSTROTH
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THE phosphate industry, as distinguished from the fertilizer industry, may be divided into three groups—viz., (1) the use of phosphoric acid as such, (2) the use of phosphate of calcium, and (3) the use of phosphate of sodium.

The only phosphoric acid of commercial importance is the ortho acid, the chemical formula being H_3PO_4 . This is sold in various densities and purities, depending upon the uses to which it is applied. The more important uses are covered in the following paragraphs.

CLARIFICATION OF SUGAR SOLUTIONS

Undoubtedly the greatest consumption of phosphoric acid as such is in the clarification of sugar juices in the sugar refineries, large quantities being manufactured for consumption in the cane refineries of this country, Cuba and South America. Various densities may be used and it must be free from arsenic and other deleterious substances. Iron and aluminum salts need not be removed to any great extent, and certain amounts of monocalcium phosphate are generally present.

Often a solution of commercial phosphoric acid, containing a certain amount of dissolved monocalcium phosphate, is concentrated to form a phosphoric acid paste, containing between 47 and 50 per cent of available P_2O_5 . This is shipped in casks, and the present prevailing price is about 10c. per lb. of available P_2O_5 . Some manufacturers produce a semi-dry mixture of commercial phosphoric acid, which has been properly purified to remove all deleterious substances, and a silicate base, such as fullers earth, Filter-cel, or kieselguhr. This semi-dry compound contains between 38 and 40 per cent of available P_2O_5 , and has the advantage that it may be shipped in the regulation flour barrels or in wooden boxes without the difficulty of leakage. It is, therefore, especially desirable for the export trade.

The advantages of phosphoric acid claimed over other clarifying agents are better color of the finished sugar, more rapid crystallization and greater yields. Phosphoric acid in this industry is called a defecating, flocculating and clarifying agent, and the process is called defecation of sugar juices. The raw sugar solution is treated first with lime, the lime combining chemically, is in turn neutralized by the phosphoric acid, an insoluble lime phosphate being formed. The flocculent precipitate is left standing to settle out, or is removed by filtration. The resultant clear solution is evaporated to the required density, cooled, and a snow-white sugar crystallizes.

JELLIES—PRESERVES—SOFT DRINKS

Considerable phosphoric acid is used in the jelly and preserving industry. Again various densities and purities are used. Acid is sometimes added to the jelly and preserve stock during the boiling period; sometimes

only a portion is added at that time, and an additional portion added at the time the jelly is poured into the glasses. This process is chemically controlled, and very exact factory control must be exercised in order to produce a uniform product. The taste and mechanical properties of a jelly are influenced by the addition of too small or too large an amount of the acid.

During the scarcity of tartaric acid and citric acid, considerable phosphoric acid was used in the preparation of soda fountain beverages and bottled soft drinks, but the requirements as to purity for this purpose are very rigid and it is claimed by some of the phosphate manufacturers that the consumption of this acid by the beverage trade is declining. One pound of high-grade phosphoric acid, containing approximately 40 per cent of P_2O_5 , or 55 per cent of H_3PO_4 , is equivalent in acidity to 0.75 lb. of commercial tartaric acid, or 0.7 lb. of commercial citric acid. Some contend that the phosphoric acid, on account of its pharmacological properties, should not be used in place of the above organic acids, while others claim that on account of the small amount of acid thus consumed by each individual it is not harmful and that on account of its much lower cost it has a distinct advantage commercially.

MEDICAL AND PHARMACEUTICAL COMPOUNDS

For the preparation of medical and pharmaceutical compounds, sirupy phosphoric acid (85 to 88 per cent H_3PO_4) is mainly in demand. This acid is fairly pure and is made entirely from phosphorus by the so-called electric furnace or distillation process. For some purposes, however, such as the manufacture of hydrogen peroxide, acids of lesser purity are suitable, some being iron free and others having certain impurities removed to suit particular requirements. In the manufacture of metal glycerophosphates, an acid of approximately 42 deg. Bé. (50 per cent H_3PO_4), sulphate free and of low mineral content is required.

A small amount of phosphoric acid, generally about 50 per cent in strength and of different purity, is used for pickling and for the manufacture of rustproofing compounds in the metal industry. An insoluble iron phosphate, it is claimed, is formed, which is not acted upon either by the oxygen of the air or affected by moisture.

MONOCALCIUM PHOSPHATE

By far the largest amount of phosphoric acid is used by the phosphate manufacturer in the production of phosphates of calcium and of sodium. Small amounts of phosphates other than calcium and sodium, such as phosphates of potassium, aluminum, ammonium and magnesium, are produced, but their use is limited.

Monocalcium phosphate, or calcium acid phosphate, $CaH_2(PO_4)_2$, finds its largest uses in the manufacture

of baking powder and self-rising flours. This industry is about 50 years old in America and today there are eleven different phosphate plants in the United States.

PHOSPHATE ROCK PRESENT RAW MATERIAL

Up to 15 years ago practically all the phosphates of calcium and sodium were made from bone, but as the consumption increased, it became apparent that, if the industry was to have a permanent growth, a product of highest purity was necessary. As a result of research work, processes were developed and perfected for the utilization of the ordinary mineral phosphate, tricalcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$, with an admixture of calcium fluoride, iron and aluminum phosphate, so extensively mined in Tennessee and Florida. Today probably 95 per cent of all the calcium phosphate going into food products is of mineral origin and is of vastly higher purity than that formerly produced. Owing to the very large capacity in this country, competition is keen and prices have practically receded to pre-war levels.

BAKING POWDER INDUSTRY

The monocalcium phosphate is considered the most economical and superior acid ingredient for baking powder manufacturing purposes. It is true that the price of sodium aluminum sulphate is lower, but a large percentage of this acid ingredient causes a better after-taste in the baked goods.

When the acid phosphate is mixed with bicarbonate of soda and corn starch in proper proportions, and after the complete reaction in baking, no disagreeable and objectionable taste or residue is left in the baked goods. The acid phosphate of calcium is universally used. Monosodium phosphate is also employed in limited quantities, but is considered to be inferior to the calcium acid phosphate for this purpose. The acid phosphate of calcium is often used in combination with sodium aluminum sulphate, cream of tartar and tartaric acid in leavening compounds, also in the compounding of cream of tartar substitutes (C. T. S.).

The granulation or size of granules of the calcium phosphate plays an important part in the action and keeping quality of a baking powder. The finer the phosphate is ground the more readily it will dissolve. When used in combination with sodium aluminum sulphate, the phosphate, being the more soluble, acts first on the bicarbonate of soda and as the baking proceeds the sodium aluminum sulphate dissolves and acts with the remaining bicarbonate of soda. The granulation of the phosphate not only influences the rate of reaction, but also determines the keeping quality of the baking powder. The phosphate manufacturers produce both a powdered and a granular grade, each grade serving its particular use and purpose. In the so-called "straight phosphate powder" a granular phosphate and soda should be used. Not only will a powdered phosphate cause premature reaction, but will also react too fast during the baking process. A baking powder produced from both powdered phosphate and powdered soda will show considerable deterioration at the end of a few weeks, while a powder produced by the use of both granular phosphate and granular soda will show very little deterioration even at the end of 6 months.

The average composition of a phosphate baking powder for household use should be as follows:

- 25 to 28 per cent bicarbonate of soda (granular).
- 33 to 37 per cent calcium acid phosphate (granular).
- 42 to 35 per cent re-dried corn starch (5 to 8 per cent moisture).

For bakery and hotel uses the formula should be:

- 30 to 35 per cent of bicarbonate of soda (granular).
- 40 to 46 per cent of calcium acid phosphate (granular).
- 30 to 19 per cent of re-dried corn starch (5 to 8 per cent moisture).

In the formula it is seen that 0.75 lb. of bicarbonate of soda is neutralized by 1 lb. of calcium acid phosphate. In other words, calcium acid phosphate is used as a neutralizing agent at a neutralizing strength of 75 per cent in terms of bicarbonate of soda. The neutralizing strength is sometimes used at 80 per cent instead of 75 per cent. Some manufacturers reduce the high strength phosphate by the addition of a high-grade corn starch, either during the wet process of manufacture or during the final standardization by mixing in a dry state. In this manner the phosphate is made to any strength desired and the method has its advantages and disadvantages.

SELF-RISING FLOUR

Thousands of tons of self-rising flour, examples of which are the prepared soft wheat flour (for hot biscuits), pancake flour and cake flour, are manufactured and consumed every year in this country. A standard formula cannot be given for preparing all the above flours. As a basis the following formula may act as a guide in the compounding of a self-rising flour. To every 92 lb. of flour and $2\frac{1}{2}$ lb. of bicarbonate of soda, $3\frac{1}{2}$ lb. of 75 per cent strength calcium acid phosphate and $2\frac{1}{2}$ lb. of edible salt; or to every 92 lb. of flour add $2\frac{1}{2}$ lb. of bicarbonate of soda, $3\frac{1}{2}$ lb. of 80 per cent calcium acid phosphate and $2\frac{1}{2}$ lb. of edible salt.

Usually the powdered soda and powdered phosphate are used, since the flour acts as the separatory agent and prevents a premature reaction and decomposition. The moisture in the flour, however, must not be too high, as it influences very materially the keeping quality of the prepared product. At no time should a self-rising flour be prepared in large quantities without first testing out the formula in a trial baking test, and the moisture and quality of all the ingredients should be carefully determined. The color and odor of the phosphate are very important, as no manufacturer of self-rising flour will permit addition of dark color or noticeable foreign odor to his product.

SODIUM PHOSPHATES

The uses of sodium phosphates in the industries is very extensive and, according to the U. S. Geological Survey, over 30,000 tons valued at about three and one-quarter million dollars were manufactured in 1920.

Monosodium phosphate has a limited use. As ordinarily manufactured, it is very hygroscopic and not suitable for either baking powder or self-rising flour. However, by a patented process it is now manufactured in a non-hygroscopic state and is used to some extent. It is considered inferior to calcium acid phosphate for these purposes.

Disodium phosphate is also a commodity used in a large way in the dyeing and textile industries, for water softening, medicinal and dental purposes and in the arts generally.

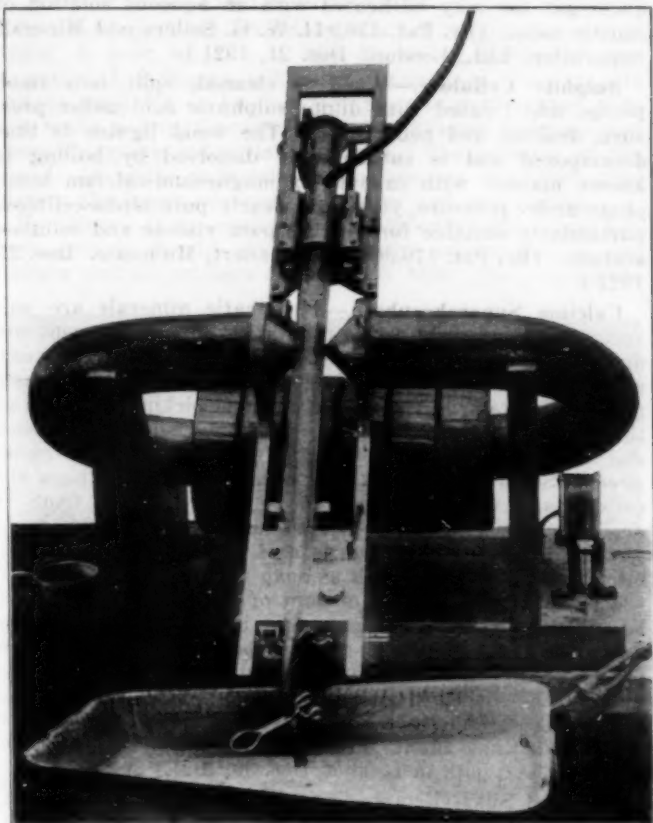
Trisodium phosphate is the most important of the sodium group. This finds extensive use in the preparation of boiler compounds in the laundry, paper industries, etc.

Acid sodium pyrophosphate is a product which finds some use in bake shops and restaurants as a substitute for cream of tartar.

Davis Tube Analyzer for Magnetic Assays

The Davis Tube Analyzer is a simple device for quickly reducing a sample of ore so that the magnetic iron percentage can be accurately computed. It was developed by E. W. Davis, head of the Experimental Mines Station of the University of Minnesota. The device is now being manufactured by the Dings Magnetic Separator Co., of Milwaukee.

Briefly, its operation is as follows: A sample of ore is placed in the glass tube, shown in the illustration,



DAVIS TUBE ANALYZER FOR MAGNETIC ASSAYS

which has previously been filled with water. The carriage bearings are placed at the poles of the magnet. A stream of water passes through the tube, washing away the tailing from the concentrate, which is held at the poles. When the washing is completed, the concentrate and tailings are dried, weighed and analyzed. A complete computation for magnetic iron may be made when the soluble iron assays of the feed, concentrate and tailing and the weight of the concentrate are known.

Summary of New Oil Companies

During December, 1921, fifty-eight new companies with individual capitalization of \$50,000 or more were organized to engage in different branches of the oil industry. The aggregate indicated capital is \$65,615,000. This compares with the November record of seventy-one such new companies with a total indicated capital of \$60,129,000. The corresponding figures for December, 1920, show ninety-five new oil companies with aggregate capitalization of \$108,680,000.

Comparing the two years, the 1921 records set forth a total of 936 companies of this character organized, with combined indicated capital of \$1,255,657,000. The 1920 figures stand at 1,712 such new companies, with combined capitalization of \$2,786,814,000.

Recent Chemical & Metallurgical Patents

British Patents

For complete specifications of any British patent apply to the Superintendent, British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Desulphurizing Gases.—Coal gas is first purified by treatment with a washing liquid such as moderately concentrated sulphuric acid or passed through charcoal to remove certain tarry constituents, and is then passed through a reaction vessel in which it is treated with active charcoal in the presence of oxygen or air. The sulphur in the gas as sulphuretted hydrogen is deposited on the active charcoal, and may be extracted by a solvent, the charcoal being re-used. A small amount of ammonia or ammonium carbonate may be added to the gas entering the reaction vessel or to the catalytic mass therein, after purification with an acid. The porous mass in the purification vessel is either replaced at intervals or revived by solvents or steam. (Br. Pat. 170,152. Badische Anilin- & Soda-Fabrik, Ludwigshaven-on-Rhine. Nov. 30, 1921.)

Slow Setting Cement.—A slow setting cement free from calcium aluminates and ferrites is prepared by adding ferric oxide to the usual ingredients of portland cement, so that the ratio of ferric oxide to alumina is between 1 and 1.563 to 1. Siliceous sand is also added to restore the ratio of silica to sesquioxides to the normal value. The materials are treated in the usual manner. (Br. Pat. 170,063. Bombini Parodi-Delfino, Rome. Nov. 30, 1921.)

Viscose Filaments.—The salts carried by or found on the threads after leaving the acid precipitating bath are recovered and utilized by washing the threads with dilute sulphuric acid so as to form the very soluble bisulphate of soda or potash, and then returning the resulting acid salt solutions, after concentration, to the precipitating bath. For the washing a 10 to 12 per cent sulphuric acid solution is preferably employed. (Br. Pat. 170,316. E. Bronnert, Mulhouse. Dec. 7, 1921. Br. Pat. 170,322 and 170,313 by the same patentee, Dec. 7, 1921, refer respectively to the addition of lactic acid to the sulphuric acid precipitating bath employed in spinning viscose filaments and to a modification in the precipitating bath in which a solution of common salt or waste stassfurt salts and sulphuric acid is used.)

Pigments.—In producing pigments consisting of a true pigment and an "extender," such as barium sulphate, by precipitating the extender in the presence of the suspended pigment or precipitating the two simultaneously, the solutions employed are so dilute or the precipitating reagent is added so gradually as to cause the formation of barium sulphate in the colloidal state. The resulting pigment is separated by filtration, dried and ground. (Br. Pat. 170,431. J. C. Smith, London. Dec. 7, 1921.)

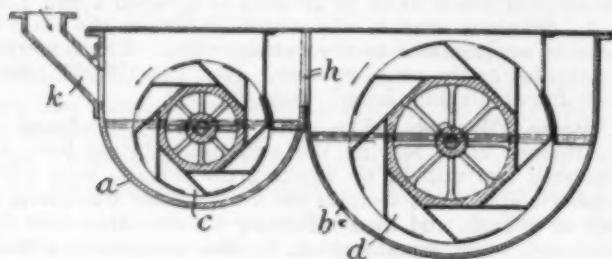
Flux for Welding Aluminum.—A flux for the autogenous welding of aluminum comprises one or more alkali halides and an activating agent which reacts with them only in the presence of aluminum oxide. An alkali pyrosulphate or pyrophosphate is employed as activating agent, a suitable mixture being potassium chloride 45 per cent, sodium chloride 30 per cent, potassium fluoride 7 per cent, lithium chloride 15 per cent, and the pyrosulphate or pyrophosphate 1 to 10 per cent. The materials are all melted together in a vessel free from metallic oxide soluble in the flux, and on solidifying a homogeneous mass remains, which is powdered. (Br. Pat. 170,343. H. V. A. Briscoe, D. Richardson and District Chemical Co., Ltd., all in London. Dec. 7, 1921.)

Urea; Fertilizers.—Urea is obtained by heating cyanamides with water and neutral or basic salts or alkali or alkaline earth metals. The water may be added wholly or in part as water of crystallization of the salt employed, or

steam may be led in; catalysts such as oxides of iron or manganese may be added, or the reaction effected under pressure. In an example, calcium cyanamide is heated with water and crystallized calcium nitrate; the calcium oxide present in commercial calcium cyanamide may be previously in part or wholly neutralized by acids such as carbonic or sulphurous acids. The products may be obtained in granular form for use as fertilizers, and there may be used in the process other salts which are themselves fertilizers—for example, potassium salts. (Br. Pat. 170,329. E. Lie and Aktieselskabet North Western Cyanamide Co., Odda, Norway. Dec. 7, 1921.)

Ammonium Sulphate.—In the production of ammonium sulphate by passing into a saturator gases which are likely to contain cyanogen compounds, the cyanogen compounds are prevented from reaching the saturator by adding to the ammoniacal liquor to be distilled a polysulphide, or forming a polysulphide in the liquor—for instance, by adding sulphur or blowing in air—so as to fix the cyanogen compounds in the liquor as sulphocyanides; or the vapor from the still may be passed over spent oxide on its way to the saturator. In the case of the direct process, the ammoniacal gas is passed through a washer containing a polysulphide solution. (Br. Pat. 170,613. South Metropolitan Gas Co. and P. Parish, London. Dec. 14, 1921.)

Recovering Gases and Vapors Absorbed in Solids.—For recovering gases or vapors absorbed in solids such as charcoal or alumina, the solid is caused to travel through a bath of liquid metal, for example of molten lead, heated to the requisite temperature, or through a series of such baths



maintained at gradually increasing temperatures so as fractionally to expel the gases; in the latter case the heated solid may be returned to the bath of lower temperature so as to carry into the latter, heat acquired in the bath or baths of higher temperature. When recovering ethylene, etc., which has been absorbed from coal or other gas, the saturated charcoal may first be passed through a bath of molten alloy maintained at about 120 deg. C., and then through a bath of molten lead at about 350 deg. C.; the charcoal is afterward cooled by passage through the first bath, through a bath of cooled mercury, or by the stripped and cooled gases; and benzene may be recovered from the charcoal of the preliminary absorbers in a similar manner, but generally these will be charged with charcoal already saturated with ethylene. A convenient apparatus comprises baths *a*, *b* arranged close together and each containing two pairs of rotating paddles *c*, *c'*, *d*, *d'*; the charcoal enters the bath *a* by a shoot *k*, is carried beneath the molten metal by the paddle *c*, falls through the adjacent openings *h* into the bath *b*, is carried there through by the paddle *d*, then passes to the other side of the bath, and is carried back in a similar manner by the paddles *d'*, *c'*, (not shown) which rotate in an opposite direction to the paddles *d*, *c*; the gases which escape are collected separately and are led away through outlets in the cover. (Br. Pat. 170,323. Thermal Industrial & Chemical Research Co. and J. S. Morgan, Westminster. Dec. 7, 1921. Br. Pat. 170,617 by the same patentee, Dec. 14, 1922, covers the application of the molten metal bath to the heating of liquids, such as tar.)

Viscose Silk.—The precipitating bath employed in the manufacture of artificial silk from raw viscose consists of sulphuric acid, which is at least partly bound to aromatic radicals. Examples are given of baths containing sodium benzene sulphonate and free sulphuric acid. The acid mixtures obtained in the direct sulphonation of benzene and its homologs, and of phenol, naphthol and their homologs may

be employed. (Br. Pat. 170,029. E. Bronnert, Mulhouse. Nov. 30, 1921. Patents 166,931 and 170,024 refer to the process of spinning, using the above precipitating bath. The use of a bath of highly concentrated solution of bisulphites with or without formaldehyde or glucose is covered by Br. Pat. 170,874, by the same patentee, Dec. 21, 1921.)

Concentration of Ores.—In a froth-flotation process, products obtained by treating viscous substances such as tars, fuel oil or tar oil with emulsifying agents such as caustic alkalis, carbonates, soaps, sodium resinate or mixtures thereof, are used as frothing agents or as a source of or in conjunction with frothing agents. For example, producer-gas tar may be heated with an aqueous solution of caustic soda. (Br. Pat. 170,944. W. G. Sellers and Minerals Separation, Ltd., London. Dec. 21, 1921.)

Sulphite Cellulose.—Wood is cleaned, split into small pieces, and treated with dilute sulphuric acid under pressure, drained and neutralized. The wood lignine is thus decomposed and is subsequently dissolved by boiling in known manner with calcium or magnesium-calcium bisulphate under pressure, yielding a nearly pure alpha-cellulose particularly suitable for making pure viscose and cellulose acetate. (Br. Pat. 170,964. E. Bronnert, Mulhouse. Dec. 21, 1921.)

Calcium Superphosphate.—Phosphatic minerals are pulverized, subjected to a froth-flotation process to separate undesirable constituents, and finally treated with sulphuric acid. In examples in which crude phosphorite and waste phosphatic material rejected after hand-picking are used as the starting material, the mineral after grinding is agitated and aerated with water containing oleic acid as the frothing agent. Sodium silicate is also added to wet effectively the constituents which are not to be floated. The froth is drained or mechanically filtered, and the resulting damp powder treated with sulphuric acid. In place of oleic acid other frothing agents such as soap may be used, and when the water is hard a small amount of sodium resinate should be added. The frothing agent may be emulsified by adding sodium oleate or sodium resinate before mixing with the mineral pulp. When it is necessary to repeat the flotation process, the concentrate is agitated and aerated with water containing sodium silicate without the addition of oleic acid or other frothing-agent. (Br. Pat. 171,155. W. Broadbridge and E. Edser, both in London. Dec. 30, 1921.)

Artificial Silk.—Relates to modifications of the processes for spinning the finest threads of viscose silk, using the ordinary spinning apertures of 0.1 m.m. diameter. According to the present invention, artificial resins prepared by the condensation of phenols with formaldehyde are added to the viscose before spinning and preferably before ripening. As spinning baths, concentrated solutions of bisulphite of soda, alone or with the addition of ammonium bisulphite, are employed and the concentration of the bath is maintained, higher according as the threads are finer. By this addition it is stated that the threads take darker shades in the dye bath, and that their resistance to water is increased. (Br. Pat. 171,125. E. Bronnert, Mulhouse, Dec. 30, 1921.)

Insulating Coatings for Metals.—In coating metal and other surfaces with phenol-formaldehyde condensation products or resins such as Bakelite and asbestos, blistering is prevented by coating the surface with the resin, applying asbestos paper or the like, hardening the resin by heat, and then impregnating the asbestos with liquid or dissolved resin which is finally hardened. (Br. Pat. 171,369. Not yet accepted. J. K. Wirth, Berlin. Dec. 31, 1921.)

Metal Carrier for Catalysts.—The carrier or support for a catalyst for chemical reactions, particularly the production of acetone from acetic acid, is made of a metal or an alloy. Aluminum is specially suitable, for by vigorously stirring the molten metal as it cools, rough porous granules are produced, upon which the catalyst can be deposited by boiling the granules in a solution or suspension thereof. For acetone production, acetic acid vapor is conducted through a tube heated to 300 to 400 deg. C., and containing as catalyst an oxide, hydrate, carbonate or acetate of calcium or barium supported upon the metallic carrier. (Br. Pat. 171,391. Not yet accepted. Stockholms Superfosfat Fabriks Akiebolag, Stockholm. Dec. 31, 1921.)

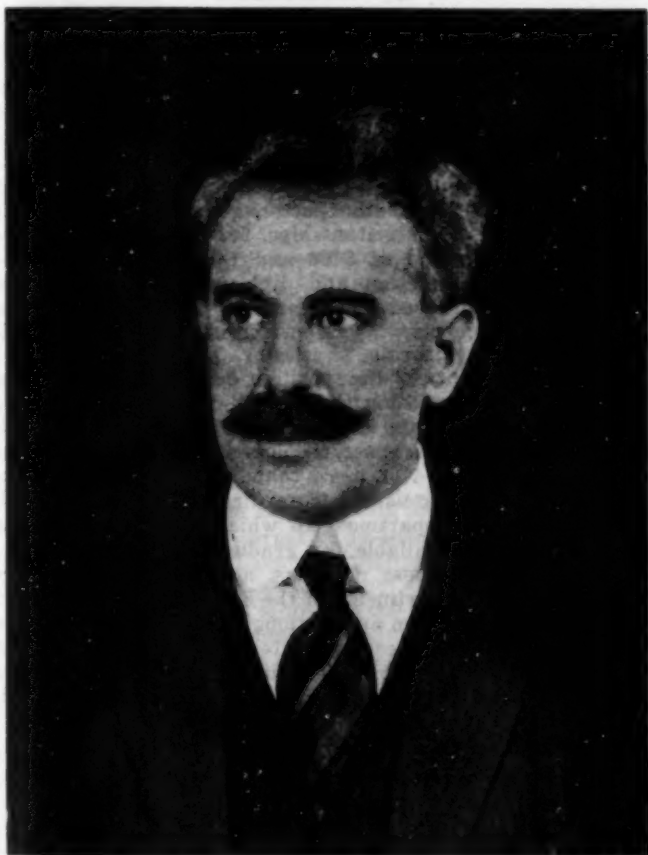
Technical News of the Week

Current Events in the Chemical, Metallurgical and Allied Industrial Fields—Legislative Developments—Activities of Government Bureaus, Technical Societies and Trade Associations

Managing Editor of Chem. & Met. to Go to Europe

In accordance with editorial plans for 1922, announced in CHEM. & MET. on Jan. 4, the Managing Editor of this magazine, J. S. Negru, will sail for Europe on Feb. 11. He will be gone for at least 6 months, and during that time will make a trip through Germany, France, Belgium and other European industrial countries. The purpose of the trip is to study industrial and economic conditions and observe the latest advances in science and engineering.

Mr. Negru is unusually well qualified to undertake this work, which should prove distinctly serviceable to the readers and advertisers of CHEM. & MET. He is a native



J. S. NEGRU, MANAGING EDITOR OF
CHEMICAL & METALLURGICAL ENGINEERING

of Europe, a graduate engineer from the University of Liège, and consequently familiar with European conditions and widely acquainted among European engineers. For the past 16 years he has spent a large portion of his time in the United States, acquiring a broad experience in American industrial practice, which will enable him to co-ordinate his observations abroad with conditions in this country. Added to this engineering and industrial experience is the fact that he has for nearly 3 years been the Managing Editor of CHEMICAL & METALLURGICAL ENGINEERING, where he has acquired our viewpoint of service to the industry.

It is expected that through Mr. Negru the magazine can reflect industrial conditions in Europe and interpret them to the mutual benefit of American and European manufacturers and consumers.

Federated American Engineering Societies Appoints Committees

The Federated American Engineering Societies has appointed a new committee on registration of engineers. The personnel of the committee is as follows: A. S. Dwight (chairman), New York; Gardiner S. Williams, Ann Arbor, and Philip N. Moore, St. Louis.

A new federal water power committee also has been named. John H. Finney, Washington, is the chairman of the committee. Other members are Calvert Townley, New York; G. S. Williams, Ann Arbor; Gano Dunn, New York, and A. P. Davis, Washington.

Dye Investigation Sub-Committee Finally Complete —Hearings to Begin Promptly

With the acceptance by Senator Ernst of Kentucky of an assignment on the sub-committee which will conduct the dye investigation recently ordered by the Senate, the early opening of the hearing is assured. The sub-committee has held an executive session at which plans for the conduct of the hearing were discussed.

It is the intention of the sub-committee to hear first the witnesses who will be called in an effort to establish that there is a monopoly in the manufacture of dyes in this country and that the domestic industry is engaged in improper activities in an effort to influence legislation. Up to the present time no date has been fixed for an open hearing and no announcement has been made as to the witnesses that will be called first.

New Head of Paper Division of Bureau of Commerce

Grosvenor M. Jones of Cleveland has been appointed by the Secretary of Commerce to be chief of the Paper Division of the Bureau of Foreign and Domestic Commerce. Mr. Jones has had considerable experience in the paper industry and trade both officially and unofficially. In 1913, before entering the service of the Bureau of Foreign and Domestic Commerce, he was engaged in a special investigation in Washington in behalf of American Paper and Pulp Association.

He was assistant director of the Bureau of Foreign and Domestic Commerce from February, 1918, to August, 1919. He has traveled in Europe and in Latin America in behalf of the Department of Commerce, studying industries, ports and shipping. Mr. Jones visited Central America in 1919 in connection with the second Pan-American financial conference. He was then appointed assistant manager of the Mercantile Bank of the Americas, followed later by appointment as director of that bank's Peruvian branch.

Mr. Jones attended Harvard University and is a graduate of Georgetown University, where he received his LL.B.

Patent Office Relief Bill Reported Favorably to Senate by Committee on Patents

The Patent Office relief bill was advanced another step in its legislative course Jan. 24 when the Senate Committee on Patents reported the bill to the Senate with the recommendation that it be passed without amendment. Senator Johnson of California, the chairman of the committee, states that every effort will be made to obtain consideration of the bill at the earliest moment.

It is understood that Senator Norris of Nebraska, formerly chairman of the Senate Patent Committee, will offer as an amendment the proposal to allow the Federal Trade Commission to administer patents for employees of the

federal government. It was this rider which killed the Patent Office bill at the last session of Congress. The chances are that the Norris amendment can be brought to a vote promptly, and if defeated the final enactment of the legislation would be a matter of a very few days. Should the Senate feel obliged, for the sake of consistency, to support its former action and vote the Norris provision into the bill, the delays incident to a divided conference committee and a possible fight on the conference report would loom.

Varnish Company Establishes Industrial Museum in Connection with Technical Library

The Murphy Varnish Co., Newark, N. J., has established an industrial museum, the first of its kind in the city, in the rooms formerly used as offices by the Essex Varnish Co., now a part of the Murphy plant, totaling about 800 sq. ft. of floor space. The museum is designed primarily for visitors to the factory, and presents an interesting exhibit of raw materials, processes and finished products of the company. A fine photograph collection sets forth methods of operation from the gathering of raw materials to different features of plant production. The finished products are displayed in company with articles upon which they have been used, such as clocks, buttons, electrical apparatus, stampings, etc. A technical library for employees at the works has been established in connection with the museum, containing about 350 volumes, pertinent to paint and varnish manufacture, selling, advertising, business methods and the like. Technical magazines and other periodicals are also on file.

Industrial Optimism Justified by Many Increases of Operating Programs

Glass.—The Allegheny Window Glass Co., Port Allegheny, near Kane, Pa., has arranged for the immediate resumption of operations at its local plant, following a shutdown for the past 13 months. Employment will be given to about 1,300 workers.

The Whitall-Tatum Co., Millville, N. J., manufacturer of druggists' glassware products, resumed operations on Jan. 17 at four of its local plants recently closed down through lack of orders.

Practically all of the glass-manufacturing plants at Tarentum and Brackenridge, Pa., are now in operation on nearly normal production schedules.

The Millville Bottle Works, Millville, N. J., manufacturer of druggists' glassware specialties, has completed the construction of a new 12-pot plant, and will place the unit in operation at once.

Paper.—The International Paper Co., New York, N. Y., will commence operations at its plant at Three Rivers, near Montreal, early in Feb., with an initial production of about 100 tons of newsprint paper per day.

Leather.—The New Castle Leather Co., Wilmington, Del., specializing in the production of morocco leathers, has increased the working force at its tannery to the normal quota of 750 persons for the first time in the past 4 years.

Tin.—The N. & G. Taylor Co., Cumberland, Md., manufacturer of tinplate, has increased the force of operatives at its local plant. The present basis of production is better than 50 per cent.

The Follansbee Brothers Co., Pittsburgh, Pa., has commenced production at its new tin mills at Toronto, Ohio. Two sheet mills at the plant were opened recently and arrangements are being made for the early operation of all departments at the plant.

Effective Jan. 17, the McKeesport Tin Plate Co., Portvue, near McKeesport, Pa., resumed operations at twenty hot mills, fifty-nine tin stacks and cold mills at its local plant, giving employment to about 1,500 workers. Operations will be resumed at other hot mills at an early date.

The American Sheet & Tin Plate Co., Farrell, Pa., has placed two additional hot mills in service at its local works, giving employment to about 100 extra men. A gradual increase will be made in production until capacity is reached.

Cement.—The Bessemer Limestone & Cement Co., Youngstown, Ohio., is maintaining capacity operations at its mills,

and has already booked orders for 200,000 bbl. for delivery in 1922, or about one-sixth of the plant capacity. It is expected that 80 per cent of the 1922 output will be sold for the year within a short time.

Zinc.—The New Jersey Zinc Co. is operating above normal production at its properties at Millport and Hazard, near Palmerton, Pa., giving employment to about 150 more men than in 1914.

Asbestos.—In connection with the maintaining of regular production at its different plants, the Johns-Manville Co., New York, has restored the 10 per cent wage cut of certain employees, placed in effect last October. The reinstatement will be operative from Jan. 1.

Iron and Steel.—The Trumbull Cliffs Furnace Co., Warren, Ohio, has blown in its new 600-ton blast furnace. The furnace and auxiliaries represent an investment of about \$3,000,000. There are more furnaces in blast in this district now than at any time since February, 1921.

The Carnegie Steel Co. is now operating five of the six blast furnaces at its Ohio mills.

The Glasgow Iron Co., Pottstown, Pa., resumed production at seven of its local puddling furnaces on Jan. 17.

The Trumbull Steel Co., Trumbull, Ohio, has increased operations from ten to nineteen mills at its plant.

University of Illinois Offers Assistantships in Engineering Experiment Station

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen research graduate assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of \$600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics or applied chemistry.

An appointment to the position of research graduate assistant is made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Not more than half of the time of a research graduate assistant is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study.

Nominations to these positions, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the director of the station each year not later than the first day of March. Additional information may be obtained by addressing the director at the University of Illinois, Urbana, Ill.

Foundrymen Change Convention Plans

It has been previously announced that the annual convention and exhibit of the American Foundrymen's Association would be held in Cleveland the week of April 24. Due to the incomplete condition of Public Hall, uncertainty as to when it would be open to the public and the manner in which it would be operated made it impossible for the city of Cleveland to give a lease for any specific date in 1922. Because of these conditions the present administration could not honor the agreements which the previous administration had entered into with the association. Rochester had previously extended a cordial invitation for this year's meeting, backed by assurances of 100 per cent support on the part of Rochester foundries and other civic bodies. All these were promptly reaffirmed by Rochester, with the result that this city has been chosen for a convention to be held during the week of June 5.

New Haven Section, A.C.S., Elects

At the annual meeting of the New Haven Section of the American Chemical Society the following officers were chosen for 1922: President, Milo C. Burt; vice-president, Treat B. Johnson; secretary, Blair Saxton; treasurer, John L. Christie; councilor, Harold Hibbert.

English and American Crucible Steels Compared at Society for Steel Treating Meeting

T. Holland Nelson, steel works manager, Henry Disston & Sons, Philadelphia, spoke before the Washington Chapter of the American Society for Steel Treating, Jan. 20, discussing American and English methods of producing high-grade crucible steels. He contrasted particularly the methods of manufacture as affecting the uniformity and real value of the product of the two countries. Emphasis was laid particularly upon the greater use of Swedish iron by the English manufacturers, not so much because of any advantage that can be revealed by analysis or microscopic examination as because practical experience indicates that a more uniform product can often be made from the Swedish iron.

Mr. Nelson also warned against acceptance of tool stock as hammered bars when really the material offered as such is only rolled bar stock given a finishing treatment under the hammer. The extra cost and extra price charged for such hammer-finished bars is not, in Mr. Nelson's judgment, at all worth while to the purchaser for tool manufacture. However, he does point out a definite advantage under some circumstances for genuine hammer stock in contrast with rolled bar stock.

Italian Chemistry Subject at Chicago Section, A.C.S.

Dr. William McPherson, chairman of the department of chemistry at the Ohio State University, spoke before the Chicago Section of the American Chemical Society, Jan. 20, on his experiences in visiting the Italian universities. Although not so well known as they deserve to be, Italian universities have behind them a history in the advancement of science that is highly commendable. Dr. McPherson spoke of the charm of the old universities where such noted men of science as Galvani, Volta and Avogadro carried on their work, many of which have the laboratories located in the courts of old monasteries, most adaptable places for such work because of their quiet atmosphere and the fireproof construction of the buildings. Dr. McPherson showed many slides of the various buildings and interiors of laboratories and spoke at length on the more noted men in Italy.

Louisiana Leads in Training Sugar Chemists

John M. Parker, Governor of Louisiana, made the following statement to the Senate Committee on Finance on Jan. 23, during the course of an argument for the tariff on sugar: "Louisiana has done more for the sugar industry of the world than any other single community. At this time we have sixty-seven men from different nations studying sugar chemistry at Louisiana State University. There, sugar chemistry has been worked out in a very advanced way and that knowledge is being utilized all over the world."

Joint Meeting of Four Societies in New York Feb. 10

"Research in Chemistry as Related to Medicine" will be the subject of an address to be delivered by Dr. Russell H. Chittenden of the Sheffield Scientific School, Yale University, before a joint meeting of the New York sections of the American Chemical Society, the American Electrochemical Society, the American sections of the Société de Chimie Industrielle and the Society of Chemical Industry on Feb. 10, at Rumson Hall, New York. The address will be followed by a discussion by C. H. Herty, H. T. Bogert and F. P. Garvan.

Water-Gas Production Costs

In a hearing before the Board of Public Utility Commissioners of New Jersey, Jan. 11, Henry D. Whitcomb, vice-president and general manager of the Public Service Gas Corporation, Newark, stated that a close estimate of the cost of production showed \$0.5304 per 1,000 cu.ft. of gas in the Essex, Hudson and Bergen divisions of the system, and for all parts of the state in which the company operates, a figure of \$0.5670 per 1,000 cu.ft. The company estimates unaccounted-for gas at 11 per cent.

U. S. Chamber of Commerce to Consider Metric System

Among the questions to be discussed at the meeting of the National Council of the Chamber of Commerce of the United States in Washington, Feb. 8 and 9, is a consideration of the advisability of legislation for the compulsory adoption of the metric system. At this time the special committee on metric system will make its report to the board of directors and the advantages and disadvantages of the adoption of the system will be presented.

The committee on railroads will also report to the directors and the railroad situation will be discussed.

Institute of Mining and Metallurgical Engineers Announces Program of 125th Meeting

The 125th meeting of the American Institute of Mining and Metallurgical Engineers will be held in New York, Feb. 20, 21, 22, 23, 1922. The first three days will be devoted to meetings of the various sections at the headquarters of the Institute, 29 West 39th Street.

Special entertainment has been arranged for evenings. On Monday evening, Feb. 20, a smoker will be held in the Engineering Societies Building. On Tuesday evening, two moving pictures, "Mexico and Its Oil" and "Through India With the Duke of Connaught, Including a Visit to the Tata Iron and Steel Works," will be shown. On Wednesday afternoon, Senator William A. Clark will open his art galleries to members and guests of the Institute. Admission tickets must be obtained at the registration desk. Wednesday evening will be devoted to the banquet.

The program of the meetings of the Institute of Metals Feb. 20 and 21 was given on page 86 of our issue for Jan. 11, 1922. Other papers of interest to our readers will be presented Wednesday, Feb. 22, in the Iron and Steel sessions.

Iron and Steel Session

10 a. m.—Room 1.

This session is in memory of Prof. J. W. Richards

Application in Rolling of Effects of Carbon, Phosphorus and Manganese on Mechanical Properties of Steel. By W. R. Webster.

Acid Open-Hearth Process for Manufacture of Gun Steels and Fine Steels. By W. P. Barba and Henry M. Howe.

Effect of Sulphur and Oxides in Ordnance Steels. By W. J. Priestley.

Electrolytic Deposition of Iron as Applied to Building Up Worn or Undersized Parts. By D. R. Kellogg.

2 p. m.—Room 2.

Effect of Time in Reheating Quenched Medium-Carbon Steel Below the Critical Range. By C. R. Hayward, D. M. MacNeil, and R. L. Presbrey.

Effect of Quality of Steel on Case-Carburizing Results. By H. W. McQuaid and E. W. Ehn.

Malleableizing White Cast Iron. By Arthur Phillips and E. S. Davenport.

Thursday will be devoted to excursions to several plants in New Jersey. The party will be divided into groups—those interested in steel, in oil and in copper. The members will ferry to Jersey City, where a special train will take the steel group to the plant of the Crucible Steel Co. of America, Harrison, N. J.; the oil group to the Bayway plant of the Standard Oil Co. (N. J.) and the copper group to the Chrome plant of the U. S. Metals Refining Co. About 2 hours will be allowed for seeing these plants. The special train will collect the different groups and take them to Perth Amboy, where they will be entertained at luncheon by the industries of Perth Amboy.

After luncheon the steel group will be given an opportunity to visit the Pardee Steel & Pardee Tile Works; the oil group the Chesebrough Mfg. Co. or the Barber Asphalt Co. and the copper group the Standard Underground Cable Co. or the Raritan Copper Works. The ladies of the party will be entertained at cards and tea during the afternoon. The groups will re-assemble at the Perth Amboy station about 4:30 p. m., for return by special train which will bring them back to New York about 5:30 p. m.

Present Status of Muscle Shoals Development —Investigation of Opposition Proposed

The report that Henry Ford has returned to the Secretary of War the contract for the lease of the Muscle Shoals water-power and nitrate plants with his signature attached presages the early consideration of the offer by Congress. Secretary Weeks has remained noncommittal as to the nature of the comment he will make in referring the proposal to Congress, but it is believed that his recommendations will carry considerable weight with the legislators. Senator Underwood has consistently maintained that the only way in which the public can obtain maximum benefit from the operation of the Muscle Shoals plants is by government operation. On the other hand, it is believed that the majority in the Senate favors a reasonable contract with responsible private interests, since government operation was blocked by the opposition of the ultra-conservationists to the formation of the proposed U. S. Fixed Nitrogen Corporation. It is expected that the proposal as it stands will be condemned by the fertilizer interests on the basis that Mr. Ford is obtaining property, in which the government has invested over eighty million dollars, at a ridiculously low figure—namely, five million dollars. Also, that in offering to pay 4 per cent on the construction cost of dam No. 2 the \$15,278,828 already expended by the government has been disregarded. The point has also been raised that the granting of a 100-year lease with renewal option during that period is directly contrary to the Roosevelt water-power policy, adopted in 1920, providing for the recapture of water-power projects by the government at the end of 50 years. The Roosevelt policy also provides for the regulation of the price of power to the consumer and that public power taken for profit shall make a return to the public. Neither of these provisions is covered by the Ford contract as it stands.

On the other hand, there is undoubtedly a strong sentiment for immediate resumption of construction work on the dam among the agricultural interests and the advocates of industrial expansion in the South. There is little doubt that if Mr. Ford's plans materialize considerable industrial activity would be fostered by the abundance of water power available, although it is probable that only a relatively small part of the power developed by dams 2 and 3 would be used for the operation of the nitrate plants in the production of fertilizer.

Briefly stated, the Ford contract as far as made public at present provides for the completion of Wilson dam and the installation of hydro-electric equipment for the generation of 600,000 hp., the construction being undertaken by the Ford organization at cost. When completed, the company would pay to the government as annual rental of the property an amount equal to 4 per cent of the total cost of construction. The company would lease the dam, power house and all equipment for a period of 100 years. At the beginning of the seventh year and annually thereafter the company would pay to the government a sum not exceeding \$39,537 to write off the cost of the dam, power house and appliances taken at \$40,000,000—the sinking fund investments to bear the highest rate of interest obtainable but not less than 4 per cent per annum. The company would pay \$35,000 annually for repairs and maintenance.

Upon the completion of dam No. 2 the government would construct dam No. 3 and its 250,000-hp. plant, the company to lease this property for 100 years, paying the government 6 per cent annually on the cost—taken at \$8,000,000—except during the first 3 years after the plant is generating 80,000 hp., when the annual payments are \$16,000, it being presumed that at the end of that period the plant will be complete and operating at full capacity. At the beginning of the fourth year of the lease period and annually thereafter the company would make amortization payments not greater than \$7,010 to write off the cost of dam No. 3, taken at \$8,000,000.

The actual purchase price of Nitrate Plants No. 1 and 2, including all equipment, patents and processes, the Waco quarry and equipment, the steam plant at Gorgas and transmission lines, is \$5,000,000. The company would have the option of renewal of water-power lease and would guarantee to operate Nitrate Plant No. 2 to approximate capacity in the production of "nitrogen and other fertilizer compounds," the maximum net profit to the company not to exceed 8 per cent. Plant No. 2 would be maintained ready for the production of war materials and turned over to the government when required in the event of war.

Active opposition to the Ford proposal is led by the National Fertilizer Association, which has recently issued a chart as one of its Truth-About-Muscle-Shoals series, which shows that only 4c. of the "fertilizer" dollar goes for sulphate of ammonia. The intention is to emphasize the association's contention that no matter how cheap sulphate of ammonia is made at the Muscle Shoals plant, it could



WILSON DAM (NO. 2) AND CONSTRUCTION CAMP LOOKING UPSTREAM ON TENNESSEE RIVER

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ABOVE—U. S. NITRATE PLANT NO. 2, MUSCLE SHOALS

1—Electric bus tunnel. 2—Water reservoir. 3—Water-treating plant. 4—Electric switch house. 5—Limekilns, coke and coal driers. 6—Raw material mixing. 7—Carbide furnaces. 8—Carbide cooling. 9—Carbide mill. 10—Cyanamide cooling. 11—Liquid air plant. 12—Cyanamide cooling. 13—Cyanamide mill. 14—Storage and hydrating. 15—Process steam plant. 16—Ammonia plant. 17—Nitric acid plant. 18—Ammonium nitrate houses. 19—Laboratories. 20—Storehouse. 21—Shops and foundry.

BELOW—NORTH END OF U. S. NITRATE PLANT NO. 2, SHOWING WILSON DAM ON TENNESSEE RIVER

22—60,000-kw. steam power plant. 23—Electric bus tunnel from steam plant to switch house. 24—Wilson dam.

not reduce the cost of fertilizer greatly. It is also pointed out graphically that it would cost \$68 a ton to make sulphate of ammonia at Muscle Shoals, whereas the average wholesale price during 1921 was \$48 per ton.

An investigation of the activities in opposition to the lease or other disposition of the government's plant at Muscle Shoals is provided in a resolution introduced in the Senate by Senator Harris of Georgia. A portion of the resolution reads as follows:

Whereas it has been charged publicly that various persons, associations, corporations and combinations interested in the production of fertilizers, commonly known as the fertilizer trust, and various persons, associations, corporations and combinations interested in the production and transmission of power, commonly known as the water-power trust, have been and are engaged in extensive propaganda and in the maintenance of a lobby to defeat any plans for and to prevent the lease or other disposition by the government of the Muscle Shoals plant and projects; therefore, be it

Resolved, That a committee composed of five Senators, to be appointed by the President of the Senate, is hereby authorized and directed to investigate such charges and activities of any such persons, associations, corporations or combinations, and to report its findings to the Senate with such recommendations as it deems proper.

Research on Motor Fuels Subject of Delaware Section, A.C.S., Meeting

"The Detonation of Gaseous Mixtures" was the subject of an address delivered by Thomas Midgley, Jr., chief engineer, Fuel Section of the General Motors Research Corporation, before the Delaware Section of the American Chemical Society in Wilmington on Jan. 16. "More miles per gallon" is a topic of almost universal interest, and the speaker explained that, as a result of his extended researches on the combustion of motor fuels, he could prescribe a never-failing method for producing the desired effect—namely, to decrease the clearance in the cylinder head and thus increase the pressure. This change always increases the power produced, but unfortunately it also causes severe "knocking."

During the study of various types of motor fuel, the speaker found that the ethers "knocked" at low pressures, then came the paraffines, olefines, aromatics and finally the alcohols, which would stand very high pressures without "knocking." Some blended motor fuels, such as benzene-gasoline-alcohol mixtures, appear to have some advantages over any one of their components used separately.

Mr. Midgley has studied a wide range of "anti-knock" compounds. Such materials as ethyl and phenyl chloride and iodide are effective, but are obviously impracticable on account of corrosion. The aromatic amines, such as aniline, toluidine, xylydine, etc., also prevent "knocking" if present to the amount of 2 to 3 per cent. The mileage of automobiles could be increased considerably by redesigning the motor to take care of motor fuels containing up to 10 per cent of aniline. The most effective "anti-knock" compound known was said to be tellurium-tetra-ethyl, but the available supply of tellurium is far from sufficient to treat the total amount of gasoline consumed.

"Chemical Education" Topic at South Jersey Section, A.C.S.

A symposium on "Chemical Education" was held by the South Jersey Section of the American Chemical Society on Jan. 19, at Carneys Point, N. J. Short papers were presented by P. W. Carleton, A. E. Houlehan, G. B. Bradshaw and W. S. Calcott, all of whom are members of the Jackson Laboratory or dyeworks staff of the du Pont company. The opinions expressed may be crystallized in the statement that the college and university training of a chemist should be merely a foundation and therefore should be as broad as possible. The general sentiment of the meeting was in favor of less industrial and applied chemistry and more thorough training in the proper use of the English language and mathematics in the modern college curriculum.

Personal

CHARLES A. BLANEY has been elected president of the Eddy Paper Co, Kalamazoo, Mich., succeeding Oscar Gumbinsky, who recently tendered his resignation on account of other pressing business interests.

ROBERT M. GATES has resigned his position as engineer with the Lakewood Engineering Co., the resignation to be effective Feb. 1. Mr. Gates has made no definite plans for the future.

CHESTER H. JONES, Industrial Editor of CHEMICAL & METALLURGICAL ENGINEERING, stationed in Chicago, is in New York for a stay of a few days.

CHARLES W. LEAVITT, consulting engineer for the Continental Asphalt & Petroleum Co., New York, is on an inspection trip to the company's properties in Oklahoma.

Dr. LESTER A. PRATT, who has been in charge of the research laboratory of the Merrimac Chemical Co. for the past 6 years, has been made director of research for the same company.

ARTHUR W. SEWALL, president of the General Asphalt Co., Philadelphia, Pa., has been elected a member of the board of directors of the Alliance Insurance Co. of that city.

EDGAR C. SHIMER, Allentown, Pa., has been re-elected president of the Brick Manufacturers' Association of Eastern Pennsylvania, Southern New Jersey and Delaware.

Dr. LUDWIK SILBERSTEIN gave a lecture on "An Optical Experiment in Connection With the Rotation of the Earth," Jan. 26, 1922, at the Franklin Institute.

HAROLD B. THORNE, vice-president of the Metropolitan Trust Co., New York, has been elected vice-president and director of the Pierce Oil Co., New York. He will relinquish his position with the trust company at an early date, but will continue as a director and member of the executive committee.

Obituary

Dr. CHARLES BASKERVILLE, director of the chemical laboratories of the College of the City of New York, died Saturday, Jan. 28, at his home, following an attack of pneumonia.

WILLIAM H. BRADLEY, chief engineer of the Consolidated Gas Co., of New York, died recently of heart disease in his office. He had been chief engineer of the company 36 years. Although eighty-four years of age, he was a daily visitor to his office. He was born in New Haven, Conn., where he received a common school education, and for several years was employed in the mechanical department of a large manufacturing establishment. Shortly after his marriage at the age of twenty-one he entered the services of the Continental Iron Works in Brooklyn as a construction engineer. That company was then actively engaged in the execution of large government contracts, and among them, in 1862, was the building of Ericsson's *Monitor*, and Mr. Bradley took an active part in the building of that new war craft, which subsequently met and defeated the *Merrimac*. At the close of the war he went to Pennsylvania, where he established a plant to manufacture oil well drilling tools, returning to the Continental Iron Works as head of the gas department in 1870. Mr. Bradley became chief engineer of the Consolidated Gas Co. 2 years after its formation in 1884, and since then had made many valuable engineering contributions to the industry. The Astoria plant, the largest in the world, was constructed under plans and specifications drawn by him. Mr. Bradley leaves a widow, a daughter, Miss Bessie Bradley; two sons, George Bradley, assistant engineer of the Nevins street plant of the Brooklyn Union Gas Co., and Charles W. Bradley, gas engineer of the People's Gas, Light & Coke Co., in Chicago, Ill.

Market Conditions

IN CHEMICAL, METALLURGICAL AND ALLIED INDUSTRIES

A Survey of the Economic and Commercial Factors That Influence Trade in Chemicals and Related Commodities—Prevailing Prices and Market Letters From Principal Industrial Centers

Business Conditions in January

January contributed but little toward the improvement of fundamental conditions in business. Readjustment continued without interruption and without any particularly significant developments.

The full forces of depression were felt by practically every branch of business. Unemployment in the chemical, iron and steel and a number of other industries has been on the increase. Business failures, always most frequent during December and January, have occurred on an unprecedented scale. The greatest number of failures in 6 years was reported in 1921. Bradstreet's number reached 2,380 in December, which was the largest monthly total ever recorded. It is customary for January to show about one-fifth more business failures than December, so that another record-breaking month is to be expected. A significant factor in the general business situation has been the availability of credit at steadily declining rates of interest. In the first week of January time money dropped to 4½ per cent and has since reached 4½ per cent. This is reported to be the lowest rate for this kind of a loan since August, 1917. Call money dropped to 3½ per cent on Jan. 6 and to 3 per cent on Jan. 9. On Jan. 16, however, the rate for call money jumped to 6 per cent and at the end of business on Jan. 26 stood at 4½ per cent. This is to be compared with 7 per cent of a year ago. A plentiful supply of credit means that working capital can be obtained with less difficulty and expense and should therefore react favorably on business.

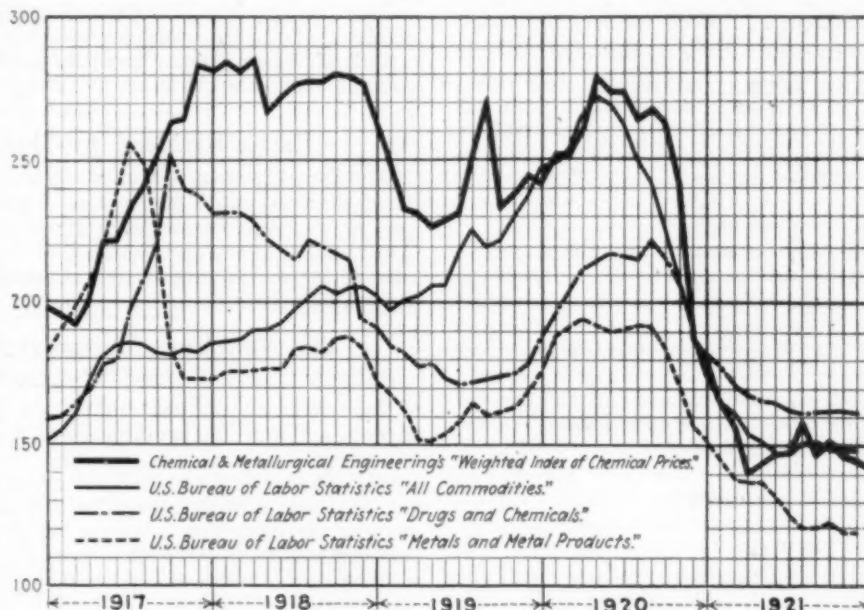
Stocks and bonds have shown some improvement of late. The *Wall Street Journal* average for twenty industrials

stood at 81.54 on Jan. 25, 1922, in comparison with a high of 81.50 and a low 63.90 for 1921.

The chemical market during January has been characterized by a continuation of the careful buying policies pursued by the consumers during the latter part of 1921. In spite of sharp price reductions there has been practically no real buying. What little demand exists has been for staples and other large-scale products rather than for specialties. Some long-time contracts have been recorded, but the number has doubtlessly been considerably less than is usual for the opening month of the year. Imports have continued to affect the market and have largely governed the prices of several important chemicals.

Price changes for particular commodities are reviewed

in this week's letter on the New York market, and the general trend in chemical prices is reflected in the CHEM. & MET. index number. For the week ended Jan. 4 this index stood at 143.30, or 3.30 more than the 5-year minimum reported in April, 1921. On Jan. 11, it was 144.49; on Jan. 18, 143.75; on Jan. 25, 143.50, and on Feb. 1, 144.60. The average for the month of January was 144.09. The uncertainty regarding the tariff situation has had a very depressing effect on the chemical industry. The failure



A COMPARISON OF WHOLESALE PRICES, 1917-1922

of the Senate to agree on a basis of valuation and Senator Smoot's prediction that the embargo on dyes would not be included in the new tariff law have discouraged trading and held production at a virtual standstill.

Wholesale Prices, 1917-1922

A graphic comparison of the prices for chemical and metallurgical products with the general average for all commodities is afforded by the accompanying chart. It is of interest to note the close relation which has existed since 1919 between the CHEM. & MET. index of chemical prices and the Department of Labor's average for over 300 commodities. These curves exhibit the same general tendencies, although there is an apparent lag of 1 to 3 months in the case of the chemical prices. Both reached the 1920 maximum in the month of April.

The indexes for metal products and drugs and chemicals also show a certain noticeable similarity. During 1919 and 1920 both were considerably under the average for all commodities. Since December, 1920, the Labor Department's index for drugs and chemicals has been 10 to 15 per cent above the general level, while on the other hand, metals and metal products have been 20 to 30 per cent under this average.

CHEMICAL & METALLURGICAL ENGINEERING'S WEIGHTED INDEX OF CHEMICAL PRICES

Base = 100 for the year July 1, 1913, to June 30, 1914

This week.....	144.60
Last week.....	143.50
February, 1921.....	166
February, 1920.....	252
April, 1918 (high).....	286
April, 1921 (low).....	140

There was a noticeable increase in the index number during the past week due principally to the higher prices for vegetable oils. Linseed oil advanced 4 cents on the gallon and cottonseed oil was up ½ cent per pound. The lower prices for caustic soda, methanol and formaldehyde failed to offset the upward movement of the index.

Decreased Output of Cottonseed Oil

Figures recently issued by the Bureau of the Census show that the production of crude cottonseed oil during the last 5 months of 1921 was about 5 per cent less than during the same period in 1920. The principal cottonseed products manufactured, shipped and in stock are shown in the following table:

	Year	On Hand Aug. 1	Produced Aug. 1 to Dec. 31	Shipped Out Aug. 1 to Dec. 31	On Hand Dec. 31
Crude oil, lb.	1921	*18,762,794	611,412,655	545,846,505	*100,167,166
	1920	22,620,357	643,566,331	543,037,678	156,088,844
Refined oil, lb.	1921	†228,263,633	‡461,488,151	†257,577,703
	1920	297,741,580	445,926,305	274,388,802
Cake and meal, tons.....	1921	36,303	900,545	679,410	257,437
	1920	133,475	897,787	787,080	244,182

* Includes 4,346,848 and 9,315,790 lb. held by refining and manufacturing establishments and 3,507,880 and 16,377,160 lb. in transit to refiners and consumers Aug. 1 and Dec. 31, respectively.

† Includes 5,884,495 and 9,638,605 lb. held by refiners, brokers, agents and warehousemen at places other than refineries and manufacturing establishments and 7,969,713 and 6,202,928 lb. in transit to manufacturers of lard substitute, oleomargarine, soap, etc., Aug. 1 and Dec. 31, respectively.

‡ Produced from 501,376,842 lb. crude oil.

Savings Resulting From Standardization

An intelligent program of standardization has been urged by the Department of Commerce because of the many ways in which it will benefit the manufacturer, distributor and consumer. Some of the direct gains to the manufacturer have been listed by the Fabricated Production Department of the Chamber of Commerce. Among those which apply to chemical manufacturers and dealers are included the following:

Gains to Manufacturers

1. Less capital tied up in
 - a Raw materials.
 - b Semi-finished stock.
 - c Finished stock.
 - d Manufacturing equipment.
2. More economical manufacturing through
 - a Larger production units.
 - b Longer runs.
 - c Simplified inspection.
 - d Cheaper handling of materials and stock.
 - e Simplified cost methods.
3. Increased efficiency of labor by
 - a Making personnel training more simple.
 - b More permanent employment.
4. Better service to trade in
 - a Controlling quality of product.
 - b Prompt delivery.
 - c Standardized packing.
5. More efficient sales force.
6. Fewer factory shutdowns.

Gains to Dealers

Those who handle chemical products in the wholesale markets might profit in the following ways:

1. Increased rate of turnover due to
 - a Elimination of slow moving stock.
 - b Concentration of sales on fewer items.
2. Decreased capital invested in
 - a Stocks.
 - b Storage space.
3. Less stock depreciation and obsolescence.
4. Decreased overhead.
5. Better service to consumers.

General Asphalt Co. Shows Large Deficit

The forthcoming annual report of the General Asphalt Co. is expected to show a loss of about \$1,000,000 for 1921. Although about half of this deficit is accounted for by arbitrary charges to depreciation and reserve accounts, the company has been severely affected by adverse business conditions and the fire at the Maurer, N. J., plant.

Since such unusual conditions cannot be expected to occur again, the directors of the company have seen no reason to discontinue payment of the preferred dividends and last week declared the regular quarterly dividend, payable March 1. The loss incurred in 1921 can easily be absorbed, since the profit and loss surplus at the close of 1920 amounted to over \$5,000,000.

The officials of the company are more optimistic regarding business for the current year. New contracts, the resumption of road-building by states and municipalities and the promising increase in building activity are all regarded as favorable factors.

The new plant erected at Maurer, N. J., at a cost of about \$3,000,000 was completed late in 1921 and has not yet had time to demonstrate the savings which will result from its greater efficiency and more modern equipment.

Industrial Reconstruction in France

The French Office for Industrial Reconstruction of the Liberated Regions has prepared a table showing the relation between productive capacity in the devastated regions at the present time and that which existed prior to the war. The percentages given for some of the principal industries are as follows:

	Production Compared With 1914 Per Cent	Labor Compared With 1914 Per Cent
Iron and steel.....	50	55
Other metallurgy.....	66	63
Chemical industries.....	58.5	62
Hides and leather.....	45	67
Textiles.....	53	55
Clothing.....	58.5	73
Mining.....	31	36

The average for all industries would appear to be about one-half of the pre-war production, but it is stated that not all of the productive capacity is effective because of the present economic crisis.

Extra Dividend by Dow Company

The Dow Chemical Co. of Midland, Mich., has declared an extra dividend of 1½ per cent on the common stock in addition to the regular quarterly dividend of the same amount. The regular quarterly dividend on the preferred stock was also declared. All dividends are payable Feb. 15 to stock of record Feb. 4.

The New York Market During January

NEW YORK, Jan. 30, 1922.

The chemical market during the past month has been something of a disappointment to those who had expected a radical improvement to follow the opening of the new year. There are a few indications, however, that the industry has been moving along the line of a gradual but rather general development. Among the outstanding features of the commodity market during January has been the steady decline in the prices of caustic soda, soda ash and the alkalis in general. However, the belief is quite commonly expressed that the bottom has been reached. The consumers have shown more attention to contracts during the past month and considerable business has been booked with the glass-making, soap and textile industries. It has been estimated that as much as 75 per cent of the regular consuming trade for alkali products is now covered by 1922 contracts.

The pronounced activity and steady demand for the prussiates has continued all during January. Yellow prussiate of potash opened at 24c. per lb. and is practically nominal on spot at about 25c. per lb. The red variety has made greater strides with a quoted advance of 3c. per lb. at the close of the month.

Another item that has been of market interest is arsenic. Leading importers who have received regular shipments from abroad have found it practically impossible to book any forward shipments for round quantities. Domestic producers are not anxious to quote at present prices, claiming the profits are too small. Opinion among large smelters is that arsenic will reach 10c. per lb. before the spring season. The opening quotation for 1922 was 6c. per lb., with a closing figure for the month of January around 7½@8c.

Linseed oil has been another commodity to show a sharp increase during the month. Opening the year at 67c. per gal. for carlots, prices reached 74c. during the past week and the market continues to be firm.

DEVELOPMENTS OF THE WEEK

Among the developments of the week has been a decline in the spot price of caustic soda. The lower prices were due to the falling off in export orders and the producers' desires to attract additional buyers. Considerable business was recently booked to Japan, Italy and South America. Business to the Orient was seriously restricted recently by increased freight rates. Sales for export were recorded at \$3.60 per 100 lb. Dealers reported a quiet movement in resale caustic at \$3.50@3.60 per 100 lb. Goods ex-store in small lots have sold up to 3½c. per lb. Producers still maintain prices at \$2.60 per 100 lb., basis 60 per cent, f.o.b. works. Exports of soda ash have been small since the beginning of the year due to English and German competition. Light ash, single bags, is moving at \$1.75@1.85 per 100 lb., depending upon the seller and quantity. Dealers are quoting barrels at \$2@2.15 per 100 lb. and report a fair movement. Producers' quotations remain at \$1.35 per 100 lb. in bags and \$1.55 in barrels, f.o.b. works, basis 48 per cent. Dense ash is being bought by the glass industry at 10c. per 100 lb. higher. Bichromate of soda has shown more activity of late and the market appeared steadier since the recent decline. Tanneries are inclined to buy only for immediate consumption. Prominent sellers quote 7½c.@8c. per lb. on spot and the same figures were named for forward shipments. Some large contract sales have gone through for delivery over the year. Producers have reduced prices on chlorate of potash to 8c. per lb. for immediate or forward deliveries, f.o.b. works. Second hands are asking 5½@6c. per lb. for spot imported chlorate and state that business is very quiet. Makers of formaldehyde have lowered their quotations to 10c. per lb. in barrels. This is a new low price for this chemical. Dealers generally quote the market around 10½c. per lb. for odd lots. Nickel salts are down to 11c. per lb. for both the double and single varieties. Manufacturers of cream of tartar have announced another sharp reduction and now quote 21½c. per lb. for the crystals and powdered U. S. P. Imported material is somewhat weaker on spot and sellers are openly quoting 23c. per lb. Owing to competition from the imported material, domestic makers of tartaric acid have again reduced prices and now quote 30c. per lb. Imported U. S. P. is still held at 25@26c. per lb. The prussiate of potash market is very strong and spot stocks of the red or yellow are difficult to locate. The red variety is nominally quoted at 33@34c. per lb. The yellow is held at 25@26c. Arsenic prices are very firm and makers quote 7½c. per lb. for limited amounts. The consuming demand is holding steady. Manufacturers of barium chloride sold several carlots early in the week at \$50 per ton, but have retracted their figure and now quote \$52 as the minimum. Importers are experiencing great difficulty in competing with American producers and ask \$53 per ton for limited amounts. Prices range all the way up to \$70 per ton, according to quantity and seller.

THE METAL MARKETS

The New York metal markets have been exceedingly dull during January, and no immediate improvement is being anticipated by leading interests. Metal products will probably not experience any marked price recessions in the next few months, but all indications are that the gradual improvement which took place around the closing months of 1921 is practically at an end. Most of the large producers of copper are quoting 14c. delivered but there are few buyers at this price. Resale merchants are doing a fair business at 13½c. on spot and second quarter delivery. The copper market on the whole was noticeably weaker owing to the fact that producers have announced the reopening of some mines and the expected early resumption of others. This has caused consumers to wait in the hope that competition would drive prices down to a lower level. The official lead price remains at 4.70c. Leading producers reported an unusually quiet week with an occasional sale noted here and there. The London price has recently declined owing to increased shipments from Australia and the possibility of imports from United States. The market on zinc continued its decline, with sales fewer and smaller in volume. The price earlier in the week was held at 4.70c. but has dropped since to 4.60c.

The Chicago Market

CHICAGO, Jan. 27, 1922.

Developments were lacking in the industrial chemical market during the past two weeks. A few items are showing an indication of strength, but for the greater part the list is dull and neglected. The tendency to shade prices on the part of weak holders is again in evidence, but this is having little if any disturbing effect on the market. Price reductions have proceeded to a point where it cannot be expected that further sharp reductions will be named in the near future. There are many items on the list which are now priced either at or below the pre-war levels and on the whole the prices existing at the moment are not so far from those prevailing in 1914.

GENERAL CHEMICALS

The alkalis are weak on spot and very little material is moving in consuming channels. Holders have announced no reductions in their schedules and are offering solid caustic soda 76 per cent at \$3.75 per 100 lb. The ground 76 per cent is quoted at \$4.50. It is very possible that with a firm order in view these prices would be shaded. Caustic potash is quiet and firm at 6½c. per lb. for the 88-92 per cent material. Soda ash is quoted lower by some holders and \$2.30 per 100 lb. for 58 per cent material in coopeage could readily be obtained.

Potash alum is quiet, with imported lumps available at 5½@6c. per lb. and the powdered at 6@6½c. White arsenic is one of the firmest items on the list and 8c. was apparently rock bottom for spot goods. Barium chloride is in but little demand and imported white crystals are quoted at \$60 per ton. Blue vitriol is moving in a fair way and is unchanged at 6c. per lb. Carbon bisulphide is quiet, with supplies available at 7@7½c. per lb. Glycerine is among the strong items and is very firm at 16½@17c. per lb. for the c.p. grade in drums.

The bichromates are moving in a routine way and apparently ample supplies are available. Potash bichromate was offered at 11½c., which is a somewhat lower figure than has been named lately. Sodium bichromate is very firm at 9@9½c. per lb. for material of standard brand. Red prussiate of potash is very scarce and material under 34c. per lb. could not be located. Potassium permanganate was in limited request and could be had at 17c. per lb. for U.S.P. crystals. Sodium fluoride is quiet and unchanged as to price at 11@12c. per lb., according to quantity and holder. Sodium hyposulphite is quoted lower by makers, the new level for pea crystals being \$3.95 per 100 lb. for single barrels.

VEGETABLE OILS

Linseed oil is reported to be moving very slowly to the consuming trade but fairly well to speculators. The boiled oil was offered today in 10-bbl. lots at 81c. per gal. and corresponding quantities of the raw at 79c.

NAVAL STORES

Turpentine is in but a very limited demand and no sales of consequence were reported today. Ten-drum lots were quoted at 92c. per gal., delivered. Rosins were reported to be moving well in carlots, but very slow in 1- or 2-bbl. quantities. The WW grade was quoted today at \$9.30 per 280 lb. in less than carlots.

The Iron and Steel Market

PITTSBURGH, Jan. 27, 1922.

It may be that the current demand for steel products is no lighter than the demand of a month ago, and it may even be that on the whole the demand is a trifle heavier, but it is quite certain that the situation is decidedly unsatisfactory and disappointing. There was universal expectation that January would show a very decided improvement in demand, not necessarily a new high rate on this movement, which began after the extreme depression of early July, but an improvement over the December showing, as December witnessed a distinct lull as compared with conditions in the 2 months preceding. Such expectation has been

disappointed. January is little if any better than December and it is not nearly as good as November or October.

Expressed in tonnage rate of production, which may be estimated roughly for the present time and is known fairly well for previous months, production of steel ingots now is at a rate of about 18,000,000 or 19,000,000 tons a year. This is to be compared with a rate of 23,000,000 tons in October and November and a rate of 20,000,000 tons in December, the rate at the close of December being lower, perhaps 18,000,000 tons.

No precise and satisfactory explanation of the condition of demand is obtainable. Reference to buyers being disposed to buy "from hand to mouth" is not explanatory, since there has been no time recently when buyers were in any other mood. There is no disclosed change in fundamental conditions that would make for lighter consumption of steel. Possibly the explanation is simply that actual ultimate consumption of steel always decreases in mid-winter and that ordinarily the decline is covered up by mills and their customers being supplied with orders for extended delivery, so that they have momentum to carry them over the lull.

PRICES UNSTEADY

The unsatisfactory condition of the steel market is not due alone to the volume of demand being light by comparison with conditions of 2 or 3 months ago. There is a weakness in prices that is decidedly menacing. The regular or asking prices are unchanged on the leading mill products, but concessions from these prices are much more common. Recently it required a good-sized tonnage to be offered to draw a price concession, whereas now concessions in the case of several products are made on relatively small orders. In some lines the regular prices scarcely obtain on orders for anything beyond carloads, and in the case of bars orders for less than carload lots go at what is considered the regular market, 1.50c.

Perhaps the clearest analysis of the situation is that the mills have got themselves into a tangle in their keenness to meet the situation and encourage distributors and consumers to go ahead. There is one cost per ton when a mill is running at one rate and another cost when it is running at another rate. In the effort to get a larger operation and thus reduce costs mills have given price concessions in keeping with the larger operation expected and have failed to get the higher operating rate, so in the effort to avoid losing money they may lose more money.

The market cannot proceed indefinitely on its present basis. Unless demand broadens it is quite probable that some mills will drop out of the competition. Demand, however, is certain to improve with the approach of spring.

Regular prices, which in some cases obtain only on relatively small lots, remain as follows: Bars, shapes and plates, 1.50c.; standard steel pipe, 71 per cent basing discount; plain wire, 2.25c.; wire nails, \$2.50; blue annealed sheets, 2.25c.; black sheets, 3c.; galvanized sheets, 4c.; tin plate, \$4.75. The sheet prices are maintained absolutely, so far as can be observed. The tin plate price is maintained as well as is usually the case. In wire products the chief weakness is that some districts have local markets of their own, having departed from Pittsburgh basing. Hoops are easier, 1.90c. being done sometimes instead of 2c. while hot-rolled strip has gone as low as 1.75c.

PIG IRON AND COKE

A lot of 1,000 tons of basic pig iron has been bought by a Pittsburgh consumer at a delivered price equivalent to \$17.75 valley, but this was resale iron, sold by a middleman, and does not make the market. On the inquiry valley furnaces quoted \$18 valley, against the former nominal market of \$18.25. Foundry iron is off 50c., the Standard Sanitary Manufacturing Co. having bought 500 tons from each of two valley producers at \$19. Bessemer is unchanged. The market is now quotable at \$19.50 for bessemer, \$18 for basic and \$19 for foundry, f.o.b. valley furnaces, freight to Pittsburgh being \$1.96.

Connellsville coke for spot shipment continues soft, with furnace coke obtainable in small lots at \$2.75 and foundry ranging from \$3.75@4.25.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride.....lb.			\$0.40 - \$0.42
Acetone.....lb.	\$0.12 - \$0.12		.13 - .13
Acid, acetic, 28 per cent.....100 lbs.	2.50 - 2.60		2.65 - 3.00
Acetic, 56 per cent.....100 lbs.	5.00 - 5.25		5.30 - 5.50
Acetic, glacial, 99 1/2 per cent, carboys.....100 lbs.	9.00 - 9.50		9.75 - 10.00
Boric, crystals.....lb.	.12 - .12		.13 - .13
Boric, powder.....lb.	.12 - .13		.13 - .14
Citric.....lb.			.43 - .44
Hydrochloric.....100 lb.	1.50 - 1.60		1.65 - 2.00
Hydrofluoric, 52 per cent.....lb.	.12 - .12		.13 - .13
Lactic, 44 per cent tech.....lb.	.09 - .10		.10 - .12
Lactic, 22 per cent tech.....lb.	.04 - .04		.04 - .05
Molybdic, e.p.....lb.	3.00 - 3.25		3.30 - 3.75
Muriatic, 20 deg. (see hydrochloric).....lb.			
Nitric, 40 deg.....lb.	.06 - .06		.06 - .07
Nitric, 42 deg.....lb.	.06 - .07		.07 - .07
Oxalic, crystals.....lb.	.14 - .14		.14 - .15
Phosphoric, 50 per cent solution.....lb.	.10 - .10		.10 - .11
Picric.....lb.	.20 - .25		.27 - .35
Pyrogallol, resublimed.....lb.			1.65 - 1.75
Sulphuric, 60 deg., tank cars.....ton			11.00 - 12.00
Sulphuric, 60 deg., drums.....ton			13.00 - 15.00
Sulphuric, 66 deg., tank cars.....ton	16.50 - 17.00		
Sulphuric, 66 deg., drums.....ton	21.00 - 22.00		22.50 - 23.00
Sulphuric, 66 deg., carboys.....ton			
Sulphuric, fuming, 20 per cent (oleum) tank cars.....ton	21.00 - 22.00		
Sulphuric, fuming, 20 per cent (oleum) drums.....ton	23.00 - 23.50		24.00 - 24.50
Sulphuric, fuming, 20 per cent (oleum) carboys.....ton	31.00 - 32.00		33.00 - 34.00
Tannic, U. S. P.....lb.			.65 - .75
Tannic (tech.).....lb.	.45 - .50		.51 - .55
Tartaric, imported crystals.....lb.			.24 - .25
Tartaric acid, imported, powdered.....lb.			.25 - .26
Tartaric acid, domestic.....lb.			.30 - .30
Tungstic, per lb. of WO.....lb.			1.00 - 1.10
Alcohol, ethyl.....gal.			4.75 - 5.50
Alcohol, methyl (see methanol).....gal.			
Alcohol, denatured, 188 proof.....gal.			.41 - .42
Alcohol, denatured, 190 proof.....gal.			.43 - .44
Alum, ammonia, lump.....lb.	.03 - .03		.04 - .04
Alum, potash, lump.....lb.	.03 - .04		.04 - .04
Alum, chrome lump.....lb.	.07 - .08		.08 - .08
Aluminum sulphate, commercial.....lb.	.01 - .02		.02 - .02
Aluminum sulphate, iron free.....lb.	.02 - .02		.03 - .03
Aqua ammonia, 26 deg. drums (75 lb.).....lb.	.07 - .07		.08 - .08
Ammonia, anhydrous, cyl. (100-150 lb.).....lb.	.30 - .30		.31 - .33
Ammonium carbonate, powder.....lb.	.07 - .07		.08 - .09
Ammonium nitrate.....lb.	.07 - .07		.07 - .08
Amylacetate tech.....gal.			2.00 - 2.40
Arsenic, white, powdered.....lb.	.07 - .07		.07 - .08
Arsenic, red, powdered.....lb.	.12 - .12		.13 - .13
Barium chloride.....ton	52.00 - 53.00		55.00 - 70.00
Barium dioxide (peroxide).....lb.	.21 - .21		.22 - .23
Barium nitrate.....lb.	.06 - .07		.07 - .08
Barium sulphate (precip.) (blanc fixe).....lb.	.03 - .04		.04 - .04
Blanc fixe, dry.....lb.	.04 - .04		
Blanc fixe, pulp.....ton	45.00 - 55.00		
Bleaching powder.....100 lb.	2.25 - 2.35		2.40 - 3.25
Blue vitriol (see copper sulphate).....lb.			
Borax.....lb.	.05 - .06		.06 - .07
Brimstone (see sulphur, roll).....lb.			
Bromine.....lb.	.20 - .21		.21 - .26
Calcium acetate.....100 lbs.	1.75 - 2.00		
Calcium carbide.....lb.	.04 - .04		.05 - .05
Calcium chloride, fused, lump.....ton	23.00 - 24.00		24.50 - 28.00
Calcium chloride, granulated.....lb.	.01 - .02		.02 - .02
Calcium peroxide.....lb.			1.40 - 1.50
Calcium phosphate, tribasic.....lb.			.15 - .16
Camphor.....lb.			.92 - .95
Carbon bisulphide.....lb.	.06 - .06		.06 - .07
Carbon tetrachloride, drums.....lb.	.10 - .10		.11 - .12
Carbonyl chloride (phosgene).....lb.			.60 - .75
Caustic potash (see potassium hydroxide).....lb.			
Caustic soda (see sodium hydroxide).....lb.			
Chalk, precip.—domestic, light.....lb.	.03 - .04		
Chalk, precip.—domestic, heavy.....lb.	.03 - .03		
Chalk, precip.—imported, light.....lb.	.04 - .04		
Chlorine, gas, liquid-cylinders (100 lb.).....lb.	.06 - .06		.06 - .07
Chloroform.....lb.			.38 - .40
Cobalt oxide.....lb.			2.00 - 2.10
Copperas.....ton	15.00 - 16.00		16.50 - 20.00
Copper carbonate, green precipitate.....lb.	.20 - .20		.21 - .21
Copper cyanide.....lb.			.58 - .60
Copper sulphate, crystals.....100 lb.	5.60 - 5.65		5.70 - 6.25
Cream of tartar.....lb.			.23 - .25
Epsom salt (see magnesium sulphate).....gal.			.58 - .65
Ethyl acetate, pure (acetic ether, 98% to 100%).....gal.			.93 - .93
Formaldehyde, 40 per cent.....lb.	.10 - .10		.10 - .11
Fullers earth, f.o.b. mines.....net ton	16.00 - 17.00		
Fullers earth—imported powdered—net ton	30.00 - 32.00		
Fusel oil, ref.....gal.			2.50 - 3.00
Fusel oil, crude.....gal.			1.50 - 1.75
Glauber's salt (see sodium sulphate).....lb.			
Glycerine, e. p. drums extra.....lb.			.16 - .17
Iodine, resublimed.....lb.			3.80 - 3.90
Iron oxide, red.....lb.			.12 - .18
Lead acetate.....lb.			.10 - .12
Lead arsenate, powd.....lb.	.15 - .15		.15 - .16
Lead nitrate.....lb.			.15 - .20
Litharge.....lb.	.07 - .07		.08 - .08
Magnesium carbonate, technical.....lb.	.06 - .06		.06 - .08
Magnesium sulphate, U. S. P.....100 lb.	2.65 - 2.70		2.75 - 3.00
Magnesium sulphate, technical.....100 lb.			1.05 - 1.80
Methanol, 95%.....gal.			.60 - .62
Methanol, 97%.....gal.			.63 - .64
Nickel salt, double.....lb.			.11 - .11
Nickel salt, single.....lb.			.11 - .11

	Carlots	Less Carlots
Phosgene (see carbonyl chloride)		
Phosphorus, red	lb. 45 - 46	47 - 50
Phosphorus, yellow	lb. 10 - 10 1/2	10 1/2 - 11
Potassium bichromate	lb. 11 - 12	12 1/2 - 15
Potassium bromide, granular	lb. 04 - 04 1/2	05 - 06
Potassium carbonate, U. S. P.	lb. 05 1/2 - 06	06 1/2 - 08
Potassium carbonate, 80-85%	lb. 06 - 06 1/2	06 1/2 - 08
Potassium chlorate, crystals	lb. 06 - 06 1/2	06 1/2 - 08
Potassium cyanide	lb. 06 - 06 1/2	06 1/2 - 08
Potassium hydroxide (caustic potash)	lb. 06 - 06 1/2	06 1/2 - 08
Potassium iodide	lb. 07 - 07 1/2	08 - 09
Potassium nitrate	lb. 14 - 15	16 - 22
Potassium permanganate	lb. 33 - 33 1/2	33 1/2 - 34
Potassium prussiate, red	lb. 25 - 25 1/2	25 1/2 - 26
Potassium prussiate, yellow	lb. 25 - 25 1/2	25 1/2 - 26
Rochelle salts (see sodium potas. tartrate)		
Salammoniac, white, granular	lb. 06 1/2 - 06 1/2	07 - 07 1/2
Salammoniac, gray, granular	lb. 06 1/2 - 06 1/2	07 - 07 1/2
Sal soda	100 lb. 1.65 - 1.75	1.80 - 2.00
Salt cake (bulk)	ton 17.00 - 20.00	
Soda ash, light	100 lb. 1.75 - 2.00	2.05 - 2.40
Soda ash, dense	100 lb. 1.85 - 1.90	1.95 - 2.40
Sodium acetate	lb. 04 - 04 1/2	04 1/2 - 05
Sodium bicarbonate	100 lb. 2.20 - 2.25	2.30 - 2.75
Sodium bichromate	lb. 07 1/2 - 08	08 1/2 - 08 1/2
Sodium bisulphate (nitre cake)	ton 4.50 - 4.60	4.65 - 5.50
Sodium bisulphite powdered, U. S. P.	lb. 04 1/2 - 04 1/2	05 - 05 1/2
Sodium chlorate	lb. 06 1/2 - 06 1/2	07 - 07 1/2
Sodium chloride	long ton 12.00 - 13.00	
Sodium cyanide	lb. 26 - 26 1/2	26 1/2 - 27
Sodium fluoride	lb. 10 1/2 - 11	11 1/2 - 12
Sodium hydroxide (caustic soda)	100 lb. 3.60 - 3.70	3.75 - 4.20
Sodium hyposulphite	lb. 06 1/2 - 06 1/2	07 - 07 1/2
Sodium nitrite	lb. 25 - 26	27 - 30
Sodium peroxide, powdered	lb. 04 1/2 - 04 1/2	04 1/2 - 05 1/2
Sodium phosphate, dibasic	lb. 17 - 17 1/2	17 1/2 - 17 1/2
Sodium potassium tartrate (Rochelle salts)	lb. 1.00 - 1.05	1.10 - 1.30
Sodium silicate, solution (40 deg.)	100 lb. 2.25 - 2.40	2.45 - 2.75
Sodium silicate, solution (60 deg.)	100 lb. 1.25 - 1.30	1.35 - 2.00
Sodium sulphate, crystals (glaubers salt)	100 lb. 04 1/2 - 04 1/2	05 - 05 1/2
Sodium sulphide, fused, 60-62 per cent (conc.)	lb. 03 1/2 - 03 1/2	03 1/2 - 04 1/2
Sodium sulphite, crystals	lb. 10 - 11	11 1/2 - 15
Strontium nitrate, powdered	lb. 05 1/2 - 05 1/2	05 1/2 - 06
Sulphur chlr. ride, red	ton 18.00 - 20.00	
Sulphur, crude	lb. 08 - 08 1/2	09 - 10
Sulphur dioxide, liquid, cylinders extra	100 lb. 2.25 - 3.10	
Sulphur (sublimed), flour	100 lb. 2.00 - 2.75	
Sulphur, roll (brimstone)	100 lb. 30.00 - 40.00	
Talc—imported	ton 18.00 - 25.00	
Talc—domestic powdered	ton 09 - 09 1/2	09 1/2 - 10
Tin bichloride	lb. 15 - 15 1/2	15 1/2 - 16
Tin oxide	lb. 08 - 08 1/2	08 1/2 - 09
Zinc carbonate	lb. 42 - 44	45 - 47
Zinc chloride, gran.	lb. 11 1/2 - 11 1/2	11 1/2 - 12 1/2
Zinc cyanide	lb. 08 - 08 1/2	08 1/2 - 09
Zinc dust	lb. 3.00 - 3.25	3.30 - 3.50
Zinc oxide, XX		
Zinc sulphate		

Paranitroaniline	lb.	.77 - .80
Para-nitrotoluene	lb.	.70 - .75
Para-phenylenediamine	lb.	1.60 - 1.65
Para-toluidine	lb.	1.10 - 1.15
Phthalic anhydride	lb.	.37 - .40
Phenol, U. S. P., drums	lb.	.12 - .16
Pyridine	gal.	1.75 - 2.75
Resorcinol, technical	lb.	1.40 - 1.50
Resorcinol, pure	lb.	2.00 - 2.25
Salicylic acid, tech., in bbls.	lb.	.20 - .21
Salicylic acid, U. S. P.	lb.	.23 - .24
Salol	lb.	.75 - .77
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 - .28
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.14 - .16
Sulphanilic acid, crude	lb.	.26 - .28
Tolidine	lb.	1.20 - 1.30
Toluidine, mixed	lb.	.32 - .38
Toluene, in tank cars	gal.	.25 - .28
Toluene, in drums	gal.	.30 - .35
Xylidines, drums, 100 gal.	lb.	.40 - .45
Xylene, pure, in drums	gal.	.40 - .45
Xylene, pure, in tank cars	gal.	.45 - .45
Xylene, commercial, in drums, 100 gal.	gal.	.33 - .35
Xylene, commercial, in tank cars	gal.	.30 - .30

Waxes

Prices based on original packages in large quantities.

Bayberry Wax	lb.	\$0.20 - \$0.21
Beeswax, refined, dark	lb.	.24 - .25
Beeswax, refined, light	lb.	.28 - .30
Beeswax, white pure	lb.	.34 - .38
Candelilla wax	lb.	.24 - .25
Carnauba, No. 1	lb.	.45 - .46
Carnauba, No. 2, North Country	lb.	.23 - .23 1/2
Carnauba, No. 3, North Country	lb.	.14 - .15
Japan	lb.	.19 - .20
Montan, crude	lb.	.04 - .05
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.04 - .04 1/2
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.02 - .03
Paraffine waxes, refined, 118-120 m.p.	lb.	.03 - .03 1/2
Paraffine waxes, refined, 125 m.p.	lb.	.03 - .03 1/2
Paraffine waxes, refined, 128-130 m.p.	lb.	.04 - .04 1/2
Paraffine waxes, refined, 133-135 m.p.	lb.	.04 - .05
Paraffine waxes, refined, 135-137 m.p.	lb.	.05 - .05 1/2
Stearic acid, single pressed	lb.	.09 - .09 1/2
Stearic acid, double pressed	lb.	.09 - .09 1/2
Stearic acid, triple pressed	lb.	.10 - .10 1/2

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.	280 lb.	\$5.40 - 5.45
Rosin E-I	280 lb.	5.50 - 5.55
Rosin K-N	280 lb.	6.15 - 6.90
Rosin W, G-W, W	280 lb.	7.00 - 7.25
Wood rosin, bbl.	280 lb.	6.25 - 6.25
Spirits of turpentine	gal.	.93 - .93
Wood turpentine, steam dist.	gal.	.91 - .91
Wood turpentine, dest. dist.	gal.	.90 - .90
Pine tar pitch, bbl.	200 lb.	6.00 - 6.00
Tar, kiln burned, bbl. (500 lb.)	bbl.	10.00 - 10.00
Retort tar, bbl.	500 lb.	9.00 - 9.00
Rosin oil, first run	gal.	.36 - .36
Rosin oil, second run	gal.	.39 - .39
Rosin oil, third run	gal.	.46 - .46
Pine oil, steam dist., sp.gr. 0.930-0.940	gal.	\$1.90 - 1.90
Pine oil, pure, dest. dist.	gal.	1.50 - 1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.46 - .46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35 - .35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.75 - .75
Pine tar, ref., thin, sp.gr. 1.080-1.960	gal.	.35 - .35
Turpentine, crude, sp.gr. 0.900-0.970	gal.	1.25 - 1.25
Hardwood oil, f.o.b. Mich., sp.gr. 0.960-0.990	gal.	.35 - .35
Pinewood creosote, ref.	gal.	.52 - .52

Fertilizers

Ammonium sulphate, bulk and double bags	100 lb.	\$2.30 - 2.60
Blood, dried, f.o.b., N. Y.	unit	3.75 - 3.75
Bone, 3 and 50, ground, raw	ton	30.00 - 32.00
Fish scrap, dom., dried, f.o.b. works	unit	3.10 - 3.20
Nitrate soda	100 lb.	2.37 - 2.40
Tankage, high grade, f.o.b. Chicago	unit	3.25 - 3.40
Phosphate rock, f.o.b. mines, Florida pebble, 68-72%	ton	5.50 - 7.00
Tennessee, 78-80%	ton	8.50 - 9.00
Potassium muriate, 80%	ton	33.00 - 34.00
Potassium sulphate	unit	1.00 - 1.00

Crude Rubber

Para-Upriver fine	lb.	\$0.21 - .21 1/2
Upriver coarse	lb.	.13 - .13 1/2
Upriver caucho ball	lb.	.12 - .12 1/2
Plantation—First latex crepe	lb.	.17 - .17 1/2
Ribbed smoked sheets	lb.	.17 - .17 1/2
Brown crepe, thin, clean	lb.	.14 - .14 1/2
Amber crepe No. 1	lb.	.16 - .16 1/2

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	\$1.00 - \$1.05
Alpha-naphthol, refined	lb.	1.15 - 1.20
Alpha-naphthylamine	lb.	.28 - .30
Aniline oil, drums extra	lb.	.16 - .17
Aniline salts	lb.	.25 - .26
Anthracene, 80% n drums (100 lb.)	lb.	.75 - 1.00
Benzaldehyde U.S.P.	lb.	1.35 - 1.45
Benidine, base	lb.	.85 - .95
Benidine sulphate	lb.	.75 - .85
Benzoic acid, U.S.P.	lb.	.60 - .65
Benzoate of soda, U.S.P.	lb.	.29 - .35
Benzene, pure, water-white, in drums (100 gal.)	gal.	.27 - .32
Benzene, 90%, in drums (100 gal.)	gal.	.27 - .29
Benzyl chloride, 95-97%, refined	lb.	.27 - .29
Benzyl chloride, tech.	lb.	.20 - .23
Beta-naphthol benzoate	lb.	3.75 - 4.00
Beta-naphthol, sublimed	lb.	.30 - .32
Beta-naphthol, tech.	lb.	.30 - .32
Beta-naphthylamine, sublimed	lb.	1.50 - 1.60
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 - .17
Ortho-cresol, in drums (100 lb.)	lb.	.24 - .26
Cresylic acid, 97-99%, straw color, in drums	gal.	.65 - .70
Cresylic acid, 75-97%, dark, in drums	gal.	.60 - .65
Cresylic acid, 50%, first quality, drums	gal.	.45 - .50
Dichlorobenzene	lb.	.06 - .09
Diethylaniline	lb.	.90 - 1.05
Dimethylaniline	lb.	.40 - .45
Dinitrobenzene	lb.	.21 - .25
Dinitrochlorobenzene	lb.	.25 - .27
Dinitronaphthalene	lb.	.32 - .35
Dinitrophenol	lb.	.38 - .40
Dinitrotoluene	lb.	.25 - .30
Dip oil, 25%, car lots, in drums	gal.	.31 - .35
Diphenylamine	lb.	.60 - .70
H-acid	lb.	.90 - 1.00
Meta-phenylenediamine	lb.	1.05 - 1.10
Monochlorobenzene	lb.	.10 - .12
Monothylaniline	lb.	1.25 - 1.30
Naphthalene crushed, in bbls.	lb.	.07 - .08
Naphthalene, flake	lb.	.07 - .08
Naphthalene, balls	lb.	.08 - .09
Naphthionic acid, crude	lb.	.65 - .70
Nitrobenzene	lb.	.10 - .12
Nitro-naphthalene	lb.	.30 - .35
Nitro-toluene	lb.	.15 - .17 1/2
Ortho-amidophenol	lb.	2.75 - 2.80
Ortho-dichlorobenzene	lb.	.15 - .20
Ortho-nitro-phenol	lb.	.75 - .80
Ortho-nitro-toluene	lb.	.15 - .20
Ortho-toluidine	lb.	.20 - .25
Para-amidophenol, base	lb.	1.50 - 1.55
Para-amidophenol, HCl	lb.	1.50 - 1.55
Para-dichlorobenzene	lb.	.17 - .18

Oils

VEGETABLE

The following prices are f.o.b. New York for earload lots.

Castor oil, No. 3, in bbls.	lb.	\$0.10	—	\$0.10
Castor oil, AA, in bbls.	lb.	.11	—	.12
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.13	—	.13
Coconut oil, Ceylon grade, in bbls.	lb.	.09	—	.09
Coconut oil, Ceylon grade, in bbls.	lb.	.09	—	.10
Corn oil, crude, in bbls.	lb.	.08	—	.08
Cottonseed oil, crude (f. o. b. mill)	lb.	.07	—	.07
Cottonseed oil, summer yellow	lb.	.09	—	.09
Cottonseed oil, winter yellow	lb.	.09	—	.10
Linseed oil, raw, ear lots (domestic)	gal.	.74	—	.74
Linseed oil, raw, tank cars (domestic)	gal.	.69	—	.70
Linseed oil, in 5-bbl lots (domestic)	gal.	.77	—	.78
Olive oil, denatured	gal.	\$1.15	—	\$1.20
Palm, Lagos	lb.	.08	—	.08
Palm, Niger	lb.	.06	—	.06
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.07	—	.07
Peanut oil, refined, in bbls.	lb.	.10	—	.11
Rapeseed oil, refined in bbls.	gal.	.83	—	.84
Rapeseed oil, blown, in bbls.	gal.	.87	—	.89
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.08	—	.08
Soya bean oil, tank cars, f.o.b. Pacific coast	lb.	.07	—	—

FISH

Light pressed menhaden	gal.	\$0.45	—	—
Yellow bleached menhaden	gal.	.48	—	—
White bleached menhaden	gal.	.47	—	—
Blown menhaden	gal.	.57	—	—

Miscellaneous Materials

All f.o.b. New York Unless Otherwise States

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	\$23.00	—	23.50
Barytes, ground, off color, f.o.b. Kings Creek	net ton	15.00	—	17.00
Barytes, crude, 88% ba., Kings Creek	net ton	10.00	—	12.00
Barytes, floated, f.o.b. St. Louis	net ton	23.00	—	24.00
Barytes, crude, first grade, Missouri	net ton	6.00	—	7.00
Casein	lb.	.15	—	.16
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	6.50	—	8.50
China clay (kaolin) washed, f.o.b. Georgia	net ton	9.00	—	10.00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	12.00	—	20.00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8.00	—	12.00
China clay (kaol.) ground, f.o.b. Virginia points	net ton	13.00	—	20.00
China clay (kaolin), imported, lump	net ton	12.00	—	20.00
China clay (kaolin), imported, powdered	net ton	25.00	—	30.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	net ton	5.00	—	7.50
Feldspar, crude, f.o.b. Maine	net ton	7.50	—	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00	—	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00	—	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00	—	21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00	—	30.00
Fullers earth, granular, f.o.b. Pa.	net ton	15.00	—	18.00
Fullers earth, powdered, f.o.b. Pa.	net ton	18.00	—	—
Graphite, Ceylon lump, first quality	lb.	.05	—	.06
Graphite, Ceylon chip	lb.	.04	—	.05
Graphite, high grade amorphous crude	lb.	.00	—	.02
Kieselguhr, f.o.b. mines, Cal.	per ton	40.00	—	—
Kieselguhr, f.o.b. N. Y.	per ton	55.00	—	60.00
Magnesite, calcined	per ton	50.00	—	65.00
Pumice stone, imported	lb.	.03	—	.40
Pumice stone, domestic, lump	lb.	.05	—	.05
Pumice stone, domestic, ground	lb.	.06	—	.07
Quartz (acid tower) first to head, f.o.b. Baltimore	net ton	—	—	10.00
Quartz (acid tower) 1 1/2 @ 2 in., f.o.b. Baltimore	net ton	—	—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	—	—	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	—	7.50
Shellac, orange fine	lb.	.68	—	.70
Shellac, orange superfine	lb.	.71	—	.72
Shellac, A. C. garnet	lb.	.58	—	.60
Shellac, T. N.	lb.	.65	—	.66
Soapstone	ton	12.00	—	15.00
Talc, paper-making grades, f.o.b. Vermont	ton	11.00	—	18.00
Talc, roofing grades, f.o.b. Vermont	ton	8.50	—	13.00
Talc, rubber grades, f.o.b. Vermont	ton	11.00	—	18.00
Talc, powdered, Southern, f.o.b. cars	ton	7.50	—	11.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	per ton	\$50.00	—	—
Carborundum refractory brick, 9-in.	less than earload lots	1,000	1250.00	—
Chrome brick, f.o.b. Eastern shipping points	net ton	1,000	1100.00	—
Chrome cement, 40-50% Cr ₂ O ₃	net ton	—	41-44	—
Chrome cement, 40-45% Cr ₂ O ₃ , sacks, in ear lots, f.o.b. Eastern shipping points	net ton	—	30-32	—
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	—	35-40	—
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	—	30-35	—
Magnesite brick, 9-in. straight	net ton	—	65-76	—
Magnesite brick, 9-in. arches, wedges and keys	net ton	—	77	—
Magnesite brick, soaps and splits	net ton	—	98	—
Silica brick, 9-in. sizes, f.o.b. Chicago district	1,000	—	38-40	—
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000	—	40-42	—
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa.	1,000	—	30-33	—

Ferro-Alloys

All f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	\$200.00	—	\$225.00
Ferrochromium, per lb. of Cr contained, 6-8% carbon, carlots	lb.	.11	—	—
Ferrochromium, per lb. of Cr contained, 4-6% carbon, carlots	lb.	.12	—	—
Ferromanganese, 76-80% Mn, domestic	gross ton	59.00	—	60.00
Ferromanganese, 76-80% Mn, Foreign, c. i. f. Atlantic seaport	gross ton	54.00	—	58.35
Spiegelisen, 18-22% Mn	gross ton	25.00	—	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2.25	—	—
Ferrosilicon, 10-15%	gross ton	38.00	—	40.00
Ferrosilicon, 50%	gross ton	54.00	—	55.00
Ferrosilicon, 75%	gross ton	115.00	—	120.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	.40	—	.45
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	6.00	—	—
Ferrovanadium, 30-40% per lb. of contained V	lb.	4.25	—	4.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	net ton	\$8.00	—	\$10.00
Chrome ore, Calif. concentrates, 50% min. Cr ₂ O ₃	ton	21.00	—	22.00
Chrome ore, 50% Cr ₂ O ₃ , f.o.b. Atlantic seaboard	ton	21.00	—	22.00
Coke, foundry, f.o.b. ovens	net ton	3.50	—	3.75
Coke, furnace, f.o.b. ovens	net ton	2.75	—	3.00
Fluorspar, gravel, f.o.b. mines, New Mexico	net ton	12.00	—	—
Fluorspar, standard, domestic washed gravel	net ton	20.00	—	22.00
Kentucky and Illinois mines	lb.	.01	—	.01
Ilmenite, 52% TiO ₂ , per lb. ore	unit	.24	—	—
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	net ton	55.00	—	60.00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂ , N. Y.	lb.	.48	—	.50
Monazite, per unit of ThO ₂ , c.i.f. Atlantic seaport	unit	27.00	—	—
Pyrites, Spanish, fines, c.i.f. Atlantic seaport	unit	.12	—	.12
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	.13	—	.13
Pyrites, domestic, fines, f.o.b. mines, Ga.	unit	.11	—	.12
Rutile, 95% TiO ₂ per lb. ore	lb.	.12	—	—
Tungsten, scheelite, 60% WO ₃ and over, per unit of WO ₃ (nominal)	unit	2.50	—	2.75
Tungsten, wolframite, 60% WO ₃ and over, per unit of WO ₃ , N. Y. C.	unit	2.75	—	3.00
Uranium ore (carnotite) per lb. of U ₃ O ₈	lb.	1.25	—	1.75
Uranium oxide, 96% per lb. contained U ₃ O ₈	lb.	2.25	—	2.50
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium ore, per lb. of V ₂ O ₅ contained	lb.	1.00	—	—
Zircon, washed, iron free, f.o.b. Pablo, Florida	lb.	.04	—	.13

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	13.75
Aluminum, 98 to 99 per cent	19.00
Antimony, wholesale lots, Chinese and Japanese	4.45
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Nickel, electrolytic, resale	33.00
Monel metal, shot and blocks	35.00
Monel metal, ingots	38.00
Monel metal, sheet bars	40.00
Tin, 5-ton lots, Straits	30.875
Lead, New York, spot	4.70
Lead, E. St. Louis, spot	4.375-4.40
Zinc, spot, New York	5.05
Zinc, spot, E. St. Louis	4.60

OTHER METALS

Silver (commercial)	oz.	\$0.65
Cadmium	lb.	1.00-1.10
Bismuth (500 lb. lots)	lb.	1.85@1.95
Cobalt	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	105.00
Iridium	oz.	170.00@200.00
Palladium	oz.	60.00-65.00
Mercury	75 lb.	48.00-49.00

FINISHED METAL PRODUCTS

Warehouse Price Cents per Lb.

Copper sheets, hot rolled	21.25
Copper bottoms	28.75
Copper rods	19.75
High brass wire	17.45
High brass rods	14.75
Low brass wire	18.75
Low brass rods	19.25
Brazed brass tubing	25.50
Brazed bronze tubing	30.50
Seamless copper tubing	21.25
Seamless high brass tubing	18.50

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current
Copper, heavy and crucible	10.25@10.75
Copper, heavy and wire	10.00@10.25
Copper, light and bottoms	7.75@8.25
Lead, heavy	3.60@3.85
Lead, tea	3.00@3.25
Brass, heavy	4.50@4.75
Brass, light	4.00@4.25
No. 1 yellow brass turnings	4.00@4.25
Zinc	2.25@2.50

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by 1/2 in. and larger, and plates 1/2 in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes	\$2.63	\$2.78	\$2.78
Soft steel bars	2.53	2.68	2.68
Soft steel bar shapes	2.53	2.68	2.68
Soft steel bands	3.13	3.28	3.28
Plates, 1/2 to 1 in. thick	2.63	2.78	2.78

*Add 15c per 100 lb. for trucking to Jersey City and 10c for delivery in New York and Brooklyn.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

PYRITON—John Boyd, R.F.D. No. 2, and associates are planning for the establishment of a new local plant for the production of commercial mica. Grinding and other machinery will be installed.

TUSCALOOSA—Officials of the local Chamber of Commerce are considering the establishment of a brick-manufacturing and clay-working plant. A company will be organized to operate the works.

California

LONG BEACH—The Long Beach Milling Co., 1058 Appleton St., has disposed of its plant site and plans for the erection of a new flour mill on property recently acquired on Willowville Ave., near American Ave., 300 x 300 ft. The new plant will include a number of work buildings in addition to the main mill. E. I. Harnett is president.

Connecticut

MIDDLETOWN—The Mohawk Mfg. Co., Waterbury, manufacturer of brass products, has purchased the factory of W. E. Stroud on College St., 50 x 100 ft., and will equip the structure for a new plant. Later an addition will be constructed.

Florida

MIAMI—The Dixie Rubber Co., Memphis, Tenn., is considering the erection of a new branch plant at Miami, estimated to cost about \$250,000, including machinery. L. C. Cadenhead is president.

CANAL POINT—The Florida Sugar & Food Products Co. is planning for the early occupancy and operation of its new local plant building, designed to increase the sugar mill output by about 400 tons a day.

Georgia

SAVANNAH—The Gulf Refining Co., Port Arthur, Tex., is planning for the construction of a new oil storage and distributing plant on Hutchinson Island, near Savannah, with capacity of about 55,000 bbl., doubling the present facilities. The work is estimated to cost about \$100,000.

Illinois

CHICAGO—The Garden City Paint & Varnish Co., Troy and 25th Sts., has awarded a contract to Frederick Marx, 1515 South Austin Ave., for the erection of a 2-story top addition to its plant, 52 x 75 ft. Work will be commenced at an early date.

CHICAGO—The Niagara Radiator & Boiler Co., Tonawanda, N. Y., has construction under way on a new foundry at 1101-13 East 83rd St., Chicago, and will occupy the structure at an early date. It will be 1-story, 130 x 400 ft., with other departments devoted to machine shop operations.

Indiana

MUNCIE—The Ball Brothers Mfg. Co., manufacturer of glass jars, etc., has broken ground for the erection of a new 2-story plant addition, 90 x 300 ft., to cost about \$100,000. A portion of the structure will be used for general manufacturing and the remainder for storage purposes. A Kibele, Johnson Bldg., is architect.

JONESBORO—The Indiana Rubber Co., First and Pearl Sts., will take bids early in the spring for the erection of its proposed 3-story plant addition, 60 x 125 ft. Plans have been drawn.

HUNTINGTON—The Huntington Chemical Co. is planning for the installation of new extraction and other equipment at its plant. A bond issue will be arranged to provide funds for the improvement. Fred H. Bowers is president, and J. L. Brenn, secretary.

Louisiana

ALEXANDRIA—The Adam Brick Co., recently organized with a capital of \$50,-

000, has acquired the local plant of C. N. Adams, and in the future will operate the property. J. H. Johnson is president and W. D. Hill, secretary and treasurer.

Maryland

BALTIMORE—The Spanish-American Cork Products Co., Westport, near Baltimore, is planning to call for bids early in the spring for the rebuilding of the portion of its plant recently destroyed by fire with loss estimated at about \$40,000. Plans will be prepared at once. O. J. Harms is president.

Massachusetts

WALPOLE—Bird & Son, Inc., manufacturer of prepared paper roofing, has awarded a contract to the M. W. Allen Construction Co., Walpole, for the erection of a 1-story addition, to be used as a paper machine department.

Missouri

JOPLIN—The Joplin Zinc Products Co., will take bids during February for the construction of a new rolling mill. It is planned also to construct a plant for the manufacture of zinc roofing shingles. R. E. Love, 1531 East 7th St., Joplin, is architect.

KANSAS CITY—The Barnsdall Refining Co. has plans under way for extensions to the blending plant at its local oil refinery, formerly operated by the Plains Oil Co.

New Hampshire

NEWINGTON—Fire, Jan. 16, caused by an explosion, destroyed a portion of the plant of the Atlantic Dyestuffs Co., including equipment, chemicals, etc. The greatest damage was done to Bldg. No. 2. An official estimate of loss has not been made.

New Jersey

BOGOTA—The Bogota Paper & Board Co. will commence the immediate erection of a new 1-story mill addition. A power house will also be constructed. The work is estimated to cost about \$42,000. Contract for the buildings has been let to the Austin Co., 217 Broadway, New York, N. Y.

NEWARK—The Orbis Products Trading Co., Wyckoff Ave., Brooklyn, N. Y., manufacturer of chemicals, oils, etc., has acquired property on Frelinghuysen Ave., extending to Virginia St., Newark, totaling about 4 acres, for the erection of a new plant. The works will consist of a series of buildings, and will be used for the distillation of essential oils and chemicals, the installation to comprise a number of mills for the grinding of gums and drugs, and auxiliary machinery. The entire plot will be utilized for the plant, plans for which will be placed under way at once.

WOODSTOWN—The South Jersey Farmers' Exchange is planning for the rebuilding of its fertilizer works, recently destroyed by fire with loss estimated at close to \$150,000. Asa Moore, Mullica Hill, N. J., is president.

NEW BRUNSWICK—The Atriken Chemical Works, New Brunswick, N. J., have leased three 1-story buildings, forming part of the plant of the Hewes & Phillips Iron Works, recently dissolved, at 12-22 Orange St., Newark, and will remove its present plant to this location. Possession will be taken at once and necessary remodeling placed under way.

JERSEY CITY—The Baker Castor Oil Co., Bay St., has filed plans for the erection of a new 2-story plant at 80 Morgan St., estimated to cost about \$25,000. Work will be commenced at once.

BRIDGETON—The Cumberland Glass Mfg. Co., manufacturer of glass bottles, jars, etc., has awarded a contract to Keeley Bros., Bridgeton, for the construction of a new plant on Laurel St., consisting of a number of 1-story buildings, estimated to cost in excess of \$1,000,000, including machinery.

KEARNY—The plant of the Stern Rendering Co., River Rd., was destroyed by fire Jan. 19, with loss estimated at about \$300,000, including buildings equipment, etc. Louis Stern is head.

New York

LONG ISLAND CITY—The Egan & Hausman Co., Inc., 476 Clinton Ave., Brooklyn, manufacturer of colors, etc., has awarded a contract to Levering & Garrigue Co., 552 West 23rd St., for the erection of a new 2-story plant, 50 x 100 ft., at Bodine and Hamilton Sts., Long Island City, estimated to cost about \$25,000. Work will be commenced at once.

NEW YORK—The Hydro-Bar Waterproofing Co. has acquired the 3-story building at 356 First Ave., now occupied, and the adjoining 4-story building at 404 East 21st St., for expansion.

NEW YORK—The Chile Copper Co., 120 Broadway, has preliminary plans under consideration for extensions in its plant to increase the output from 15,000 to 35,000 tons a day. The work will be commenced as soon as conditions warrant.

North Carolina

GREENSBORO—The Pomona Terra Cotta Co., has commenced the erection of a new factory, to be known as Plant No. 4. It will consist of a number of buildings, with main structure, 70 x 225 ft. Other structures will approximate 30 x 50 ft. A total of 8 new kilns will be installed at the plant, each about 36 ft. in diameter. W. C. Boren, Jr. is secretary and treasurer.

ALBEMARLE—The City Council is having plans prepared for enlargements in the filtration plant at the municipal waterworks. Gilbert C. White, Durham, N. C., is consulting engineer.

WINSTON-SALEM—George D. Hodgkin, Winston-Salem, is planning for the construction of a new brick- and tile-manufacturing plant on site now owned at Daisy, near Winston-Salem.

Ohio

WARREN—The K. W. Brick Co., 607 Home Savings & Loan Bldg., Youngstown, O., will soon commence the erection of a new brick manufacturing plant at Warren, to be 1- and 2-story, 70 x 150 ft., and estimated to cost about \$30,000. J. Whitaker is president.

Oklahoma

OKLAHOMA CITY—The Process Refining Co., recently organized with headquarters at Oklahoma City, has acquired the plant of the Firtle-Pittman Refining Co., at Newkirk, Okla. A number of improvements will be made to the refinery, including the installation of a new refinery process. A. C. Heiden is vice-president; and C. H. Hyde, secretary and treasurer.

HENRYETTA—The Harper Oil & Refining Co., recently incorporated with a capital of \$200,000, has commenced excavations for a new oil refinery, on property purchased in the southwestern section of the city. A 10-acre tract of land has been secured for the plant, which will have an initial capacity of about 1,000 bbl. per day. J. P. Harper is president, and E. D. Ham, secretary.

ARDMORE—The Choctaw Oil & Milling Co. is said to be planning for the rebuilding of the portion of its plant, recently destroyed by fire with loss estimated at about \$40,000.

Pennsylvania

OIL CITY—The Oil Well Supply Co. will install a large electric steel furnace in one of the new buildings now being erected at the plant.

PHILADELPHIA—The Glenwood Industrial Distilling Co. has taken title to the 1-story and basement building on Cedar St., near Tioga St., and will use the property for a local works. It was obtained for a consideration said to be \$35,000.

PITTSBURGH—Bethlehem Laboratories, Inc., a \$5,000,000 corporation, has been organized here to manufacture a new antiseptic known as Hyclorite, possessing 175 times germicidal strength of hydrogen peroxide. Among incorporators are Homer D. Williams, president of Carnegie Steel; Taylor Allerdice, vice-president of National Tube; and Dr. J. J. Reilly, surgeon, United States Shipping Board. Plans include construction of modern chemical plant here.

Rhode Island

CRANSTON—Fire recently destroyed a portion of the local plant of the Graphite Mines Corp., with loss estimated at about \$100,000, including buildings, equipment and stock.

Tennessee

DAYTON—The Dixie Coal, Lime & Clay Products Co., recently organized with a capital of \$750,000, O. E. Thomas, Dayton,

president, has plans under way for the erection of a large brick- and tile-manufacturing plant at Graysville, eastern Tennessee district, where extensive property has been secured. The initial works will have a capacity of 50,000 bricks per day, with departments for tile and stoneware manufacture. The company is planning also for the construction of a hydrated lime-producing plant, with initial capacity of about 50 tons daily.

Texas

THREE RIVERS—J. E. Jarrett and C. H. Kearney, Three Rivers, are organizing a company for the construction and operation of a local plant for the manufacture of glass products. Plans will be prepared at an early date.

LAREDO—The Kirk Refinery Co., San Antonio, has construction under way on a new plant at Laredo, for the manufacture of lubricating oils. The company has secured a site near the shops of the Texas-Mexican Railway Co. The refinery will have an initial output of about 1,200 bbl. per day, and will handle crude oil from the Miranda oilfield. E. W. Kirkland, San Antonio, is president; and R. B. Thomas, Tulsa, Okla., secretary and treasurer.

DALLAS—The Davis Mfg. Co., Knoxville, Tenn., manufacturer of chemical products, has completed plans for the erection of a new branch plant at Dallas, to be 3-story, and estimated to cost about \$50,000. Contract will be let and the work commenced at an early date. Grover C. Davis is president and general manager.

YOAKUM—The Texas Hide & Leather Co., is planning for the erection of an addition to its plant for sole leather and other leather manufacture. The company is arranging for an increase in capitalization to \$200,000. J. B. Harris is manager.

Washington

SPOKANE—The Bentley Paste Co., Minneapolis, Minn., has commenced work on a new branch plant at Spokane, for the manufacture of paste and kindred products. It will be ready for service at an early date.

West Virginia

NITRO—The Rubber Service Laboratories Co., Akron, O., has acquired a site at Nitro, for the construction of a new plant for the manufacture of chemical and affiliated products, to be used in connection with rubber vulcanizing work. Carl N. Hand, Nitro, is local representative for the company.

New Companies

THE K. S. T. NOVELTY CO., New York, N. Y., has been incorporated with a capital of \$400,000, to manufacture celluloid and composition products. The incorporators are M. Grehman and I. Siper. The company is represented by J. G. Kremer, 233 Broadway, New York.

KNELLER, VAUGHN & CO., INC., New Haven, Conn., has been incorporated with a capital of \$50,000, to manufacture liquid metal cleaners and other chemical products. The incorporators are Charles S. Vaughn, Henry S. Kneller and Frank H. Kasperon, 332 Norton St., New Haven.

THE HARBOR PRODUCTS CO., Carlstadt, N. J., has been incorporated with a capital of \$10,000, to manufacture chemicals and chemical byproducts. The incorporators are J. F. C. Grow, H. G. Boardman and Frederick L. Locke, Carlstadt.

THE M. S. CHEMICAL CO., 1131 Stevens Bldg., Chicago, Ill., has been incorporated with a capital of \$50,000, to manufacture carbon removers, cleansers and other chemical products. The incorporators are Milton L. Smith, Norman H. Pritchard and William P. McCracken, Jr.

THE GULF & REFINERS' CORP., New York, N. Y., has been incorporated under Delaware laws with capital of \$1,000,000, to manufacture petroleum products. The company is represented by the United States Corporation Co., 65 Cedar St., New York.

THE SAN-NOX CHEMICAL CO., Birmingham, Ala., has been organized under state laws to manufacture chemicals and chemical byproducts. James Johnson is president; J. G. Dickinson, vice-president; and H. H. Smithson, secretary and treasurer, all of Birmingham.

THE BRUCE MARVIN CHEMICAL CO., Boston, Mass., has been incorporated with a capital of \$10,000, to manufacture chemicals and chemical byproducts. Joseph A. Conway is president; and Joseph J. Crotty, 185 Columbus Ave., Boston, treasurer.

THE F. E. M. MFG. CO., New York, N. Y., has been incorporated with a capital of

\$10,000, to manufacture chemicals and affiliated products. The incorporators are J. Baker, J. Levy and I. Kaplan. The company is represented by A. E. Schwartz, 140 West 42nd St., New York.

THE ILLINDA OIL CO., Breckenridge, Tex., has been incorporated with a capital of \$350,000, to manufacture petroleum products. The incorporators are G. E. Stocking, W. E. Bowler and Fred Phipps, all of Breckenridge.

THE UNIVERSAL CHEMICAL CO., Wilmington, Del., has been incorporated under state laws with capital of \$1,000,000, to manufacture chemicals and chemical byproducts. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

THE BAYONNE STEEL PRODUCTS CO., Bayonne, N. J., has been incorporated with a capital of \$250,000, to manufacture steel and other metal products. The incorporators are Harry B. and Charles H. Dembe, 216 Jelliff Ave., Newark, N. J.

THE JAMES H. COOPER CO., INC., Westborough, Mass., has been incorporated with a capital of \$50,000, to manufacture leather products. James R. Cooper, 11 Beach St., Westborough, is treasurer.

THE CONTINENTAL CERAMICS CORP., New York, N. Y., has been incorporated with a capital of \$10,000, to manufacture pottery and other ceramic products. The incorporators are W. S. McKay, L. E. Hellman and V. L. Weldon. The same incorporators have also formed the ROSENTHAL CHINA CORP., with capital of \$10,000, to manufacture and deal in chinaware. Both companies are represented by S. F. Hartman, 120 Broadway, New York.

THE SAVANNAH CHEMICAL CO., Savannah, Ga., has been incorporated under state laws to manufacture chemicals and chemical byproducts. The incorporators are George L. Groover and W. B. Stratford, both of Savannah.

THE SEA LEATHER & OIL CORP., Caldwell, N. J., has been incorporated under Delaware laws with capital of \$6,300,000, to manufacture leather products, oils and affiliated specialties. The incorporators are Frank C. Myers, Caldwell; Charles W. Owen, Hackensack, N. J.; and Robert Strange, Orange, N. J. The company is represented by the United States Corporation Co., 65 Cedar St., New York, N. Y.

THE NEWTON CHEMICAL CO., Newton, Mass., has been incorporated with a capital of \$25,000, to manufacture chemicals and chemical byproducts. Charles G. Pickett is president; and William Hahn, Newton Centre, Mass., treasurer.

THE CARBON DIOXIDE PLANT FOOD CO., St. Augustine, Fla., has been organized under state laws to manufacture fertilizer products. W. B. Guy is president; Robert Ranson, vice-president; and R. D. Crawley, secretary and treasurer, all of St. Augustine.

IRELAND & HOLMES, INC., New York, N. Y., has been incorporated with a capital of \$20,000, to manufacture pulp and paper products. The incorporators are W. H. Holmes, C. H. Ireland and K. C. Newman, 38 Park Row, New York.

THE AMERICAN OIL CO., fourteenth floor, American Bldg., Baltimore, Md., has been incorporated with a capital of \$2,250,000, to manufacture petroleum products. The incorporators are Louis and Jacob Blaustein, and Alvin Thalheimer.

THE CALCO CHEMICAL CO., New York, N. Y., has been incorporated with a capital of \$5,000, to manufacture chemicals and chemical byproducts. The incorporators are R. C. Jeffcott, G. A. Berry and W. G. Heath. The company is represented by S. C. Morehouse, attorney, New Haven, Conn.

THE EVANSVILLE PAINT & VARNISH CO., Evansville, Ind., has been incorporated with a capital of \$50,000, to manufacture paints, varnish, etc. The incorporators are H. D. Bourland, Arthur C. Heberer and E. L. Fowler, all of Evansville.

THE PLYMOUTH RUBBER CO., Canton, Mass., has been incorporated with a capital of \$150,000, to manufacture rubber products. Maurice J. Hamilburg is president; and Reuben B. Gryzmish, 70 Marshall St., Boston, treasurer.

THE NO RUB AUTO POLISH CO., Newark, N. J., has filed notice of organization to manufacture polishes and other chemical products. Joseph Lardiere, 132 Summer Ave., heads the company.

THE FRIENDS OIL CO., Wilmington, Del., has been incorporated under state laws with capital of \$100,000, to manufacture petroleum products. The company is represented by the Corporation Service Co., Wilmington.

Capital Increases, etc.

THE TIDAL OIL CO., Tulsa, Okla., has filed notice of increase in capital from \$52,000,000 to \$102,000,000.

THE MATTHIESSEN & HEGELER ZINC CO., La Salle, Ill., has filed notice of a reduction in capitalization from \$426,000 to \$310,000.

THE EASTERN MFG. CO., Lincoln, Me., manufacturer of bleached sulphite pulp and paper products, has disposed of a bond issue of \$2,500,000, for financing, general operations, etc. Stuart W. Webb is chairman of the board.

THE TODD SALT CO., 409 East 8th St., New York, N. Y., has filed notice of increase in capital to \$40,000.

THE HAWK OIL CO., Tulsa, Okla., has filed notice of change of name to the Wrightsman Petroleum Co. The company is organized under Delaware laws.

THE UNION SOAP CO., 214 North Pearl St., Baltimore, Md., has filed notice of reduction in capital from \$50,000 to \$12,000.

Frederick J. Telovitz has been appointed receiver for the GOODWEAR LEATHER MFG. CO., INC., Raritan, N. J.

THE ALBANY OIL CO., Tulsa, Okla., has filed notice of increase in capital from \$12,000 to \$250,000.

THE DERBY DOME-WYOMING OIL CO., St. Louis, Mo., has filed notice of increase in capital from \$50,000 to \$1,500,000.

THE GUANTANAMO SUGAR CO., 129 Front St., New York, N. Y., has arranged for a new preferred stock issue to total \$1,500,000.

Coming Meetings and Events

AMERICAN CERAMIC SOCIETY will hold its twenty-fourth annual meeting at St. Louis, Feb. 27 to March 3, 1922.

AMERICAN CHEMICAL SOCIETY will hold its spring meeting at Birmingham, Ala., April 4 to 7, 1922.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Baltimore, April 27, 28 and 29, 1922.

AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its next convention and exhibit at Rochester, N. Y., during the week of June 5, 1922. Meetings will be held in the spring instead of in the fall as heretofore.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York the week of Feb. 20, 1922.

AMERICAN SOCIETY FOR STEEL TREATING, sectional meeting, Friday, March 3, Engineering Societies' Building, New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS will hold its twenty-fifth annual meeting June 26 to July 1, at Atlantic City, N. J. Headquarters will be at the Chalfonte-Haddon Hall Hotel.

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY will hold a meeting at Lyons, France, June 27 to 30.

IRON AND STEEL INSTITUTE (British) will hold its annual meeting on May 4 and 5 at the House of the Institution of Civil Engineers, Great George St., S. W., 1, London.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stettens Restaurant, 843 Broad St., Newark, N. J., the second Monday of every month.

NORTHWEST MINING ASSOCIATION will hold a convention in the Chamber of Commerce Bldg., Spokane, Wash., Feb. 14 to 18.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Feb. 10—American Electrochemical Society (in charge), Society of Chemical Industry, Société de Chimie Industrielle, American Chemical Society, joint meeting; March 10—American Chemical Society, Nichols Medal; March 24—Society of Chemical Industry, regular meeting; April 21—Society of Chemical Industry (in charge), American Electrochemical Society, Société de Chimie Industrielle, American Chemical Society, joint meeting; May 5—American Chemical Society, regular meeting; May 12—Société de Chimie Industrielle (in charge), American Chemical Society, Society of Chemical Industry, American Electrochemical Society, joint meeting; May 19—Society of Chemical Industry, regular meeting; June 9—American Chemical Society, regular meeting.